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BRITISH COLONIAL DEVELOPMENT

THE debate in the House of Commons on January 20 on the occasion of the third reading of the Overseas Resources Development Bill was poorly attended ; the apparent lack of interest was the more remarkable, since, as Mr. Creech Jones quite rightly said in moving the third reading, the Bill had the general support of all political parties and had been acclaimed with some enthusiasm outside the House. The Secretary of State for the Colonies asserted, indeed, that the Bill was as much designed for the purpose of meeting the needs of the world as for meeting the special needs of the Colonial peoples. As Sir Frank Stockdale pointed out in a discourse at the Royal Institution on January 23 (see p. 337), it marks a further big step forward in the British conception of Colonial development, from the social and economic schemes planned under the Colonial Development and Welfare Acts of 1940 and 1945, in exploiting the economic resources for the general development of these territories.

Mr. Creech Jones said he is satisfied that, under the Bill, the needs of Great Britain and Western Europe will not dominate the essential development requirements of the Colonial peoples themselves, and no apprehension need be felt that the provision for an Overseas Food Corporation will divert us from the main purpose of building up Colonial standards. The intervention of the Minister of Food, through the establishment of this Overseas Food Corporation, in matters that should be the responsibility of the Colonial Secretary was the main point at issue in the debate. Mr. Creech Jones believes that the creation of such corporations can give enormous assistance to enterprise ; and in announcing that on the Colonial Development Corporation, the chairman, Lord Trefgarne, would have the support of Sir Frank Stockdale as full-time deputy-chairman, he showed that, as Mr. Oliver Stanley said later, the Government is calling on people of exactly the character and experience which seem desirable. Others who have accepted the invitation to join the Board include Mr. E. C. Tansley, formerly marketing director of the West African Produce Control Board, Sir Miles Thomas and Sir Charles Darwin. Mr. J. Rosa, who was on the Commission of the East African groundnut scheme, links up the Board with the Overseas Food Corporation.

Before making this latter announcement, the Minister of Food had again rejected amendments designed to exclude the Overseas Food Corporation from the Colonial territories, or to enable its projects to be transferred to the Colonial Development Corporation. Mr. Strachey was not altogether convincing as to why two Corporations should be necessary, and he did not dispose of the argument that the Government has allowed to stray into Colonial affairs a by-product of its own failure to deal with the large and vital question of the organisation of government and the division of functions and responsibilities at the highest level, on which the Select Committee on Estimates commented so pointedly in a recent

report. For the rest, however, there was only welcome for the general purpose of the Bill, though some wished to see an industrial development scheme linked up with the activities contemplated in the present Bill. While it was obvious that welfare considerations were prominent in the minds of members generally, and that it was the intention of the House that the Development Corporation should use its powers to promote the health and nutrition of the Colonial peoples and to further the prevention as well as the cure of disease, it was equally clear that they had not forgotten the close connexion between our ability to develop Africa and the survival of Britain, to which the Chancellor of the Exchequer had referred.

There are, however, very real dangers in the pace at which political development is proceeding. Their reality is well indicated in a recent book by Mr. O. Awolowo*. Its forthright definition from the African side of the common purpose for which the British and the Nigerians have to work is the product of hard thinking as well as of strong feeling; and even if the latter sometimes tends to discolour the thought and lead to some misinterpretation of the facts, as Miss Perham suggests in her foreword, that does not detract greatly from the inherent value of the book. The book, moreover, has a certain representative importance; as Mr. Awolowo believes that concurrent developments in the Gold Coast are not limited in their significance to Nigeria, so the mental 'climate' of the Nigerian people has an importance far beyond Nigeria. Any constructive contribution from the Colonial peoples has a general as well as a local and particular significance, particularly in meeting the demands which the Colonial situation makes upon our intelligence and the continuous attention which for some reason or other the House of Commons seems unable to give.

The importance of this factor is well brought out by Miss Perham. The main barriers between the British and the small educated minority among the Nigerians and other Colonial peoples are psychological rather than in the sphere of practical politics. This, of course, underlines the importance of that policy of expansion of higher education in the Colonial Empire to which we have already committed ourselves as a result of the reports of the Asquith and Elliot Commissions on Higher Education in the Colonies and in West Africa. But it means also that we should bend our energies and intelligence to the achievement of self-government within the British Commonwealth with something of the sense of urgency which Mr. Awolowo attaches to it, and with a new resolution to make the task of administrative education succeed.

Mr. Awolowo's book deserves attention; but it should be remembered that co-operation along this path involves obligations not only upon the part of the British but also upon the Africans themselves. Moreover, that co-operation is seriously hindered by the distortions of history which propaganda continues to disseminate.

* Path to Nigerian Freedom. By Obafemi Awolowo. Pp. 137. (London: Faber and Faber, Ltd., 1947.) 7s. 6d. net.

Here, as so often elsewhere, propaganda is a deadly enemy of real advance and achievement; it is most effectively countered by accurate knowledge, and the whole trend of Colonial development in recent years has brought the scientific worker into a position where he must not only be increasingly responsible for supplying much of the factual knowledge required, but also himself needs for the execution of his duties more background knowledge of the political and economic situation in which his scientific contribution is being made. It will be noticed, for example, that Mr. Awolowo, who recognizes that the best interests of the coloured peoples lie in co-operating wholeheartedly with those white groups which support their development, considers health and education to be the only important functions of government which the coloured peoples can at present discharge with efficiency. Here Mr. Awolowo's book is often suggestive even where he may be biased and perhaps subconsciously not quite accurate in his presentation. But to the trained mind accustomed to sift and weigh evidence, his frankness and sincerity, his appreciation of the British, for all his impatience, give his book a real value in understanding the mind of the Colonial peoples.

No one who followed the debate in the House of Commons on January 20 could doubt the reality of the desire for effective co-operation between the Colonial and the British peoples, or of the appreciation of the extent to which such co-operation must depend on the calibre of those responsible for handling the educational, labour and medical sides of the work of the Overseas Food and the Colonial Development Corporations. Like the admirable survey of Colonial administration during the war years and the opening phase of reconstruction which the Colonial Office issued last year*, it afforded an impressive tribute to British policy and administration during that time of stress. Unlike that Blue-book, however, the debate testified to the support which the new developments have drawn from all parties of the House of Commons, and indicates once more that differences of opinion as to method or detail have not hindered support for the general policy or impeded the flow of constructive suggestion.

This comprehensive Blue-book is valuable from several points of view. It replaces the annual reports on the work of the Colonial Office, publication of which, interrupted by the War, is now to be resumed. In addition, it has the merit of bringing out certain consequences of the impact of the War common to all the Colonies in spite of the differences in their material fortunes. The very prominence which such developments as the East African groundnut scheme and the plan for the development of Uganda give to particular aspects makes it important that such projects should be seen in perspective against the broad background of general policy and those features in the British Colonial Empire which are independent of race and place.

This is the more important because, on one hand, of the increasing approach to Colonial affairs by

* The Colonial Empire (1939–1947). (Cmd. 7167.) (London: H.M. Stationery Office, 1947.) 2s. 6d. net.

international collaboration, quite apart from the influence of the Trusteeship Council of the United Nations, and, on the other, because a number of studies of special aspects of the problems of particular areas require consideration against that general background; many have their own contribution to make to the solution of the general problem or of specific problems in other areas. A comprehensive perspective is important in appraising the significance of some of the recent changes and moves in government, such as the appointment of Lord Listowel as Minister of State for the Colonies, and Mr. H. A. Marquand's mission to Africa to discuss general trade developments with the Union of South Africa and Southern Rhodesia, and other developments in regional organisation outlined in this survey. The appointment to West Africa of a resident Minister of Cabinet rank has, for example, been perpetuated in the formation of a West African Council of the Governors of the four colonies, with its permanent secretariat, and the Conference on West Indian Federation in Jamaica last September over which Mr. Creech Jones presided, are no less notable as evidence of Britain's readiness to place her unrivalled political experience at the disposal of the Colonial peoples in their progress to self-government.

Such steps indicate how fully the Government appreciates that the changed needs of the time call for an increasing devolution of authority, as well as for the closer integration of government on democratic lines. Moreover, the whole range of government has to be extended so that it may become the instrument of economic and social as well as of political development. Sir Stafford Cripps told the Governors' Conference in November that we are to increase out of all recognition the tempo of African development. Accordingly, just when it is important that new developments of democratic institutions should be firmly based and suited to the capacity of the peoples concerned, it has become imperative that the far-reaching changes involved in the relations of governors and governed should be carried through as expeditiously as possible. Any undue time-lag between new legislative and administrative conceptions in Britain and their application to Colonial policy may, indeed, become a positive danger.

NUCLEAR PHYSICS IN PHOTOGRAPHS

Nuclear Physics in Photographs

Tracks of Charged Particles in Photographic Emulsions. By C. F. Powell and G. P. S. Occhialini. Pp. ix + 124 (50 plates). (Oxford: Clarendon Press; London: Oxford University Press, 1947.) 18*s*. net.

THE epoch-making discoveries in the field of nuclear physics during the past thirty years have been predominantly due to the development and use of methods of detection of single fast-moving nuclei and electrons. In the experiments of Lord Rutherford upon the scattering of α-particles which established the concept of the nuclear atom, in the discovery of the neutron and of artificial transmutation, and in the more recent investigations upon cosmic rays leading to the discovery of the positron and the meson, the part played by the detectors of single charged particles and quanta has been universal and indispensable. It is, therefore, very surprising to reflect that practically all this work has been done with only four basic techniques: the scintillation screen, the Geiger counter, the ionization chamber plus amplifier and the expansion chamber.

For a long time the possibility of direct recording of the tracks of ionizing particles in photographic emulsions has been recognized, but until the immediate pre-war years comparatively few serious experiments had been made by this technique owing to its limitations and insensitivity. During the past ten years, however, Dr. C. F. Powell and his collaborators at the University of Bristol have taken a leading part in the application of this method to a wide range of nuclear investigations, and, with important improvements in the production of more suitable emulsions by Messrs. Ilford, this technique now ranks in power and efficiency with the counter and expansion chamber. The publication of a book by these authors, illustrating so clearly the present potentialities and limitations of the method in expert hands, is, therefore, noteworthy and welcome.

The volume under notice is not, however, a detailed account either of the techniques of preparation and processing of the emulsions or of the experimental arrangements for exposure and measurement of the plates. It is rather, as implied by the title, an album of fifty beautiful photomicrographs illustrating a great variety of nuclear processes. In the brief space of seventy pages of text, the authors make a praiseworthy effort not only to explain the particular phenomena recorded in the photographs, but also to give an elementary account of atomic and nuclear structure and of the basic phenomena of nuclear physics and cosmic rays. It is only natural that such a limited text will confine the educational value, in a formal sense, to students and school teachers, and even for these the absence of phenomena concerning electrons, which are not recorded by this technique, causes a grave lack of generality and balance. However, such criticism is perhaps unreasonable. The avowed purpose of the authors is to present nuclear phenomena in "the robust form and vivid colouring of physical illustrations" which has greater appeal to many minds than purely mathematical expressions. This volume will, I think, be best appreciated by those who can travel, in imagination, with the meson along the tortuous path in the photograph and wonder at the events transpiring at its brief halting point.

Despite the textual limitations, therefore, the authors are to be congratulated on having produced a volume which every experimental nuclear physicist will wish to possess, together with the "Atlas typischer Nebelkammerbilder", by Gentner, Maier-Leibnitz and Bothe, which plays a similar part in relation to work which has been done with the expansion chamber. These two volumes have a beauty both of subject-matter and of artistry of reproduction comparable in every way with that of the illustrated books which are so common in the realm of the fine arts. Scientific workers can use them to refute the narrow dogma that "Science deals with facts and Arts with values", which is frequently advanced by their classical friends. We should, indeed, do well to persuade these latter to add these volumes to their own libraries.

P. I. DEE

PHYSICAL PATTERNS OF SPEECH

Visible Speech

By Ralph K. Potter, George A. Kopp and Harriet C. Green. (Bell Telephone Laboratories Series.) Pp. xvi + 441. (New York: D. Van Nostrand Co., Inc.; London: Macmillan and Co., Ltd., 1947.) 25*s*. net.

As pointed out by Dr. Oliver E. Buckley in the foreword to this book, improvement in the telephone and extension of its service are the principal aims of research in the Bell Telephone Laboratories. It is well known, however, that from these Laboratories have come many other devices which have been of very considerable value to the community quite apart from the use of the telephone. It will be recollected that, shortly before the War, Homer Dudley published the results of fundamental research which had been carried out there on the formation of speech sounds. This may have applications in the future in the field of long-distance telephony. A little later another instrument was devised for the analysis of speech sounds and named the 'sound spectrograph'. This background, which does not appear in the book, makes the development which it describes the more interesting.

The title of the book, "Visible Speech", is the same as that of a book published by the father of Alexander Graham Bell, the inventor of the telephone. The elder Bell's work, however, was only concerned with the use of hand-written symbols which would define the accenting of words more precisely. The sound spectrograph, on the other hand, is essentially a device for making recorded patterns showing the frequency and intensity of the components in short samples of speech. As a first stage in its operation, the speech is recorded on a magnetic tape or by other means. The recorded sample of speech is then scanned electrically many times in succession by means of a circuit which includes a variable-frequency band-pass filter. The result of this analysis may be presented as a photographic record in which time is represented horizontally, frequency vertically and the intensity of the sound by the density of the record. Such records are useful in a study of speech sounds; but in order to enable the deaf to carry on a conversation more direct presentation of the speech in visual form is needed. Various means of doing this are possible: the final result in one case is presented on the screen of a cathode ray tube.

The techniques do, however, make possible methods of depicting speech sounds in such a way that they can be comparatively easily recognized. They have been explored as a means of conveying the information in speech sounds to the totally deaf, and of teaching them to speak by way of training them to reproduce the patterns. It is interesting to note that some of the most useful contributions to the later work have been made by a congenitally deaf engineer. The early part of the book is largely concerned with the description of the patterns which are produced by the basic sounds in speech. The relationship of these fascinating patterns to the use which the speaker makes of his different speech organs, and the basic phonetic principles underlying the patterns, are discussed; information bearing clues which enable a student to recognize and interpret them are pointed out. Although to a beginner the vowel sounds are distinctive, it would seem to him that long practice would be needed to pick out the consonants which convey so much of the information in speech.

The second part of the book, and the bulk of its pages, are occupied by lessons units copiously illustrated with patterns of American speech. This part has been written to be studied by the adult who wishes to learn how to read visible speech, and is adapted to one who either has hearing, or has relatively recently lost hearing, so that sounds and words may be recalled. To be appreciated it must be studied carefully and the various sounds practised and imitated from the patterns.

The experimental work that has been done so far has provided assurance that the patterns of visible speech are distinctive and can be interpreted. It has indicated that visible speech can possibly be used in the speech and general education of the deaf. It is fair to say, however, that a great deal of work so far has been with subjects who have been capable of quickly appreciating the speech patterns; but the practical value of visible speech as a means of making contact with the normal deaf person of no more than average education and intelligence has yet to be evaluated. As the authors say, the primary purpose of the book is that of turning over to all those who would carry on the work the major results and development to date.

This book can be unreservedly recommended to all those who have a specialist's interest in speech sounds, and in particular to those who are intimately concerned with the interests of the deaf. 'Visible speech' may also have other more varied applications, both as a research tool or for more widespread use; but these will emerge later. W. G. Radley

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MODERN RADIO TECHNIQUE

(1) A Survey of the Principles and Practice of Wave Guides

By Dr. L. G. H. Huxley. (Modern Radio Technique Series.) Pp. xi+328. (Cambridge: At the University Press, 1947.) 21*s*. net.

(2) Radio Aids to Navigation

By Dr. R. A. Smith. (Modern Radio Technique Series.) Pp. xii+114+7 plates. (Cambridge: At the University Press, 1947.) 9*s*. net.

The introduction of radar and the widespread development of radio wave technique during the past ten years have resulted in a considerable addition to our knowledge and experience, the records of which were confined during the war years to confidential and secret reports. Much of this information has recently been published in the form of scientific and technical papers in the proceedings of societies and institutions. There is clearly a need in addition, however, for a more compact form of publication in which the information on various aspects of the subject is collected together in separate volumes or books. It is therefore gratifying to note the proposal by the Cambridge University Press to publish a new series of monographs under the editorship of Mr. J. A. Ratcliffe and dealing with the advances in radio technique made during the War. All the monographs are being prepared by men who were personally responsible for important advances in the subjects they write about; two volumes have already been published, and some six more are in active preparation.

(1) Although the subject of the propagation of electric waves in metal tubes—or wave guides as they are now called—has been studied theoretically

for some fifty years, it was not until radar technique began to be developed on centimetre wave-lengths that the subject suddenly became of outstanding practical importance. Dr. Huxley was, during the War, head of the Radar School of the Telecommunications Research Establishment, and thus had a unique opportunity of becoming fully acquainted with the development of the subject, and the manner in which it should be treated for teaching purposes. The first six chapters of his book are based on courses of instruction on microwave techniques given at the above School, while the seventh and last chapter contains a more systematic mathematical treatment of various matters dealt with earlier.

This is a very satisfactory arrangement, for the reader who is not mathematically inclined will find that the early chapters, which comprise about three-quarters of the book, provide an extremely clear exposition of the phenomena associated with wave guides, and of the many practical applications of wave-guide systems. The reader is introduced to the conception of the transmission of waves having electric or magnetic field components in the direction of transmission by considering the superposition of the fields of a series of transverse waves travelling at an angle to the axis of the guide and being subjected to repeated reflexions from its walls. The phenomena of multiple-mode transmission and the frequency cut-off characteristics of wave guides are also clearly described. Among the practical topics dealt with in Chapters 4 and 5 are standing-wave detectors, crystal mixers, wave-guide couplers and matching transformers, means of producing circularly polarized waves, and the behaviour and use of slots cut in the walls of the guide. These two chapters occupy nearly half the book, and will be found invaluable by those who have to use wave guides as an essential part of any equipment for centimetre wave-lengths.

Chapter 6 deals with cavity resonators and their various applications, whether as tuned elements in oscillators in place of the conventional lumped circuits, as wavemeters or as echo boxes which are resonators of very low decrement, which when shock-excited by a pulse continue to 'ring' or emit a radio signal for an appreciable time after the cessation of the exciting pulse. This chapter also contains an indication of the manner in which resonant cavities may be used in the measurement of dielectric properties of materials of interest to the radio engineer and physicist.

The book is well produced and liberally illustrated, and it is to be recommended to all classes of reader interested in wave guides; and those concerned with practical applications will find the physical treatment most illuminating.

(2) The author of the second book, Dr. R. A. Smith, also has the advantage of being a member of the staff of the Telecommunications Research Establishment, where remarkable developments in radio technique took place during the war years, following the successful application of pulse technique to the detection and location of aircraft, ships and other objects. The field of radio navigational aids is nowadays very wide, and the author has, perhaps wisely, made no more than a brief mention of the use of medium- and high-frequency direction finding, and the associated developments in radio beacons and radio ranges for course-indicating purposes. Furthermore, the book is, on the whole, concerned with the navigation of aircraft, although some reference is made to the problems of navigation at sea in the two chapters on "Long-Range Navigational Aids" which deal with pulse and continuous wave systems respectively.

Within these limitations, Dr. Smith has provided an interesting account of the radio navigational aids developed primarily in Great Britain. The style throughout is descriptive, and in parts almost of a historical narrative nature; and to the reader with some general knowledge of the subject, the monograph forms a most useful and concise survey of this particular field of development. The author has quite rightly omitted all circuit diagrams and technical details; but sufficient values are given of the performance of the various systems to enable an appreciation to be made of the relative merits and fields of application of these navigational aids, some of which are now being adapted to the needs of civil aviation and merchant shipping.

It is very satisfactory to see material which has hitherto been scattered over a number of published papers and confidential reports collected together and presented in this way for the general scientific reader. For the benefit of those who wish to delve deeper into the subject, some references are given to recent detailed publications, many of which are the result of the Radiolocation and Radiocommunication Conventions held by the Institution of Electrical Engineers in 1946 and 1947 respectively.

R. L. Smith-Rose

MODERN INORGANIC CHEMISTRY

Modern Advances in Inorganic Chemistry

By E. B. Maxted. Pp. vii + 296. (Oxford: Clarendon Press; London: Oxford University Press, 1947.) 20*s*. net.

THE last two or three decades have seen very substantial advances in inorganic chemistry, as regards both technique and the fundamental concepts on which the subject is based. Any volume which succeeds in making a critical survey of the field so opened up is therefore most welcome.

Most needed at the present time, perhaps, is a concise account of the physical background to inorganic chemistry, which would enable the student to obtain a sufficient grasp of atomic and nuclear physics to follow current developments in the theory of valency and in artificial radioactivity. The first chapter of Dr. Maxted's book sets out to provide such an introduction, but, unfortunately, falls short in several particulars of what might well have been achieved. It is surely essential that the account should be authoritative, and that points settled beyond any reasonable doubt should be presented in a clear-cut manner. In this respect the section on nuclear structure is not at all satisfactory; it contains a number of cautious understatements of well-established facts, coupled with a few rather positive assertions on matters which are by no means finally settled. The remainder of this chapter is devoted to an account of modern ideas of valency, as developed by Pauling and others.

The following chapters give more detailed accounts of recent work on a few specialized topics. Some of these subjects are dealt with in a completely satisfactory manner—the chapter on the "Recent Chemistry of the Halogens", for example, appears to be unexceptionable—and it is therefore all the more disappointing to have to record that this state of

affairs does not appear to extend to some questions for which a more critical outlook is required.

Perhaps the most serious example occurs in the chapter "Masurium and Rhenium". Here, the author does not appear to be at all perturbed by the absence of any confirmation of the claim of Noddack and Tacke to the discovery of element 43. The reviewer feels that the very least that should be done in this case is to make it abundantly clear that the existence of stable isotopes of this element is still an open question. The uncritical reproduction of published work is evident also in the discussion of the hydrogen isotope of mass 3. The author records the abundance of tritium in ordinary water as about 7 parts in 10^{18}, as reported by Selwood, Taylor, Lozier and Bleakney; he does not appear to wonder how so short-lived an atomic species (its half-life is about thirty years) could continue to exist even in this small concentration. In point of fact, subsequent experiments led Bleakney and his collaborators to retract their claim in favour of a much lower figure for the upper limit of abundance, and yet more recent work has set the upper limit at 1 part in 10^{17}.

The remainder of the purely inorganic part of the book calls for little comment: Chapter 4 on hafnium, and the remainder of Chapter 5, on rhenium, are quite satisfactory; the chapter on the halogens has already been commended. Hydrogen and deuterium are given a fairly adequate treatment in Chapter 2, although on one or two occasions a distinct misplacement of emphasis is apparent. Chapter 6 contains a very useful account of "Reactions in Discharge Tubes", a subject which, hitherto, has tended rather to be neglected.

The book concludes with two chapters inspired by the current interest in nuclear reactions: "The Preparation and Uses of Artificial Radioactive Elements" and "Uranium and the Transuranic Elements". For a superficial study of these two related topics these chapters give an adequate account, although it cannot be claimed that the treatment is outstanding. From the book as a whole one is tempted to draw the conclusion that, human fallibility being what it is, reviews covering so wide a range of topics should be a co-operative effort on the part of two or more authors. G. R. MARTIN

EXPERIMENTAL STUDY OF HUMAN HEALTH

Biologists In Search of Material

an Interim Report on the Work of the Pioneer Health Centre, Peckham. Edited by Dr. G. Scott Williamson and Dr. I. H. Pearse. Second edition. Pp. 107 + 2 plates. (London: Faber and Faber, Ltd., 1947.) 5s. net.

THE aims of the Peckham Health Centre are nowadays so well known that they need no explanation here. The plan was to offer to families living within a specified area containing about 5,000 families a health service in the form of a family club, supported by a weekly subscription which is now 2s. per family. This doubling of the original subscription was suggested by old members of the Centre themselves. The details given in this book of the health examinations made show that the families participating obtain for this small subscription a very valuable service. But the scheme would be fundamentally misunderstood if it were thought that it seeks to replace or compete with other health services. It is essentially a biological experiment of a very interesting kind. With the full co-operation of each family it studies this social unit together with its environment, and it is claimed for it that it has also great social and educational value and can be used for the training of medical and social workers.

A short review can do no more than indicate the kind of results so far obtained and direct attention to the originality of the minds which direct the whole experiment. Stating, for example, that the efficiency of medical services depends primarily upon diagnosis, the authors of this book remind us that the first diagnosis is made by the patient. The medical man can do nothing until the patient, because he suffers from pain, discomfort, disability or limitation of action, seeks advice; and observations made at the Centre indicate that the patient seeks treatment, not because of his subjective state of disease, but because he is aware of his social incapacity. The word 'disease' is here used as meaning only the subjective state of the sufferer, the objective facts discovered by the medical man, such as adenoids, rickets, pneumonia, and so on, being called 'disorders'.

The authors' analysis of the condition which they call 'well-being' also presents some interesting observations. Well-being, they claim, can mask both grave and minor disorders. An instance of the former is the youth aged twenty-one, who said he had never felt better in his life and who was able, because he was ambitious to become a boxer and a gymnastic champion, cheerfully to sustain valvular disease of the heart, nephritis, high blood pressure and albuminuria. He compensated, as the authors put it, for his body's shortcomings, but only at considerable cost to his body. The dangers of this kind of compensation, which produces, often at a great price, a balanced action of the whole organism, are well described. This state of well-being, which deceives both the patient and the casual observer, is differentiated from the state of health which exists when the organism is not turned in on itself to effect a compensation, but is exerting an adaptive function to the whole situation and operates on the environment rather than upon itself.

Interesting also is the view that the general practitioner and the outpatients' departments and dispensaries of the hospitals treat maladies in order to relieve the social inconveniences of the patients, such as pain, discomfort, and so on; whereas the specialist tends to study the malady as if it were a detached objective thing. The practitioner thus becomes a highly skilled craftsman in the relief of social disabilities associated with disease, and this is what the patients demand of him. "But it is very clear," say the authors, "that what the public demands and gets from the practitioner is not what the State, the friendly societies and the industrialists expect of the doctor." Nor is this all that the medical man, when he emerges from his training, hopes to give.

Certainly the further progress of this experiment will be watched with the greatest interest. The subsidy required per head at the present expensive experimental stage is £4 15s. per year, a figure which may be compared with the calculation made in this book that £6 per head of the population is wasted every year through illness. The claim is made that, given time, the Centre can be made self-supporting. Let us hope that the solution of this problem of time and money, which is, the book says, the major one still remaining, will quickly be found. G. LAPAGE

FACTORS OF AGRICULTURAL PRODUCTION IN THE BRITISH COLONIAL EMPIRE*

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CONSIDERABLE interest is now being taken by Great Britain in colonial development. This interest has been further stimulated by the Government's decision during the past year to undertake the East African groundnut scheme and to establish a Colonial Development Corporation and an Overseas Food Corporation. The latter, when constituted, will take over the operations of the East African ground-nut scheme and start other food production projects overseas, while the Colonial Development Corporation will deal with developmental projects of a widely varying character throughout the colonial territories—the importance of which has been emphasized in recent months by the difficulties which are being experienced by Britain in the balance of dollar payments.

It is, however, well to realize that this decision by the Government to establish a Colonial Development Corporation is but another advance in Britain's colonial policy, which is designed to improve the standard of living of the colonial peoples, to extend their social services and to advance political self-government. The British people are convinced that the standards of life of the colonial peoples must be raised and that better economic standards in colonial territories will provide expanding markets and a general improvement of world trade.

Improved standards of life cannot be obtained or better social services maintained without expanded production. Indeed, the emphasis in the activities of Colonial Governments in the future is certain to be in the developmental field, and to be directed towards the utilization of the natural resources of the territories to the fullest extent possible, coupled with a general advancement of their peoples.

Looking at the colonial territories as a whole, the one outstanding feature which calls for comment is the very considerable increase of population during the past twenty to thirty years. It is rapidly becoming apparent that the present systems of production may very shortly be unable to provide sufficient food for satisfactory nutritional standards for these increasing populations and that marked changes in the methods of production must be made. In certain places, particularly in Eastern and Central Africa, soil erosion has assumed alarming proportions, and considerable areas, through pressure on the land and by poor systems of agricultural husbandry and stock keeping, have been rendered incapable of further production for many years.

Food will, undoubtedly, figure prominently in the requirements of the future and must be given the highest place in colonial policy. At the same time, if standards of living are to be raised, commercial crops must be grown and a more diversified production established.

I propose here to limit myself to a consideration of some of the factors which influence agricultural production under colonial conditions. They may be dealt with under the following headings: climate, soils, water, systems of agriculture, use of livestock, crop varieties, pests and diseases of man and his stock and crops, marketing arrangements and social organisation.

* From a Friday Evening Discourse at the Royal Institution delivered on January 23.

Climate

The climates of the British Colonial Empire range from the super-humid of the tropical rain belt with its heavy forest, through the humid with its lesser forest or parkland vegetation to the sub-humid with grass-covered savannas and thence to semi-arid steppe or desert with sparse vegetation. Climate, after all, plays the part of master influence on agricultural activities and production, and it determines not only the major soil zones, but also the systems of agriculture which prevail.

In the eastern group of Colonies, the climate of Malaya, Sarawak and North Borneo may be classified as super-humid and that of Ceylon either super-humid, humid or sub-humid according to aspect and altitude. In the West Indies, and the continental territories of British Guiana and British Honduras, the range is similar to that of Ceylon, but there are occasionally years of serious drought.

A study of Africa reveals wide climatic belts which range from super-humid to the semi-arid. Types of vegetation and the agricultural crops correspond to a greater or lesser degree with the different climatic belts. In West Africa, dense equatorial forest covers the coastal regions of the Gold Coast and Nigeria, and extends throughout French Equatorial Africa into the Congo basin. North of this equatorial rain forest occur zones which pass from humid and sub-humid to arid, with corresponding tall grass savanna, dry savanna or desert. In East Africa, humid regions occur as coastal or lake belts, sub-humidity prevailing elsewhere except where influenced by altitude. In Uganda, the area with a humid climate exceeds that under sub-humidity which is characteristic of the other East African territories. At the higher altitudes in East Africa, as well as in the Central African territories, there are zones of mountain forest and grasslands with variable rainfall.

Production in the tropical rain belt with an annual rainfall in excess of 80 in. includes timbers and forest products, oil palms, coconuts, rubber, cacao, bananas, sugar, rice and certain root crops, whereas the production of the drier forest, parkland or grass savanna areas with rainfalls ranging from 30 in. to 60 in. includes coffee, cotton, yams, maize, millets, groundnuts and livestock, and in the areas of low rainfall millets are grown and livestock are found to predominate. In the higher altitudes with rainfalls of 60 in. or more, tea and wattle flourish, and where the rainfall is lower, coffee and some of the crops of temperate zones thrive.

Soils

These cover a wide range and naturally vary in composition according to the nature and age of the rocks from which they have derived. Laterites are common. They contain an appreciable quantity of iron concretions—sometimes resembling lumps of iron ore and sometimes small pebbles. They are caused by the leaching of iron salts from the upper soil layers and their subsequent re-oxidation around particles of quartz. In many areas, particularly where the climate is humid or sub-humid, definite hard pans are formed and these have to be watched for with care. Tropical soils generally are acid in reaction, especially in the wetter areas and where not derived from limestone. Some crops require soils of

acid reaction for maximum production and will not thrive when the lime content in the soil is high, while others only prosper where the soils are neutral or only slightly acid in reaction. Throughout the soils of the tropics a deficiency of nitrogen is widespread. Phosphatic deficiency also occurs over wide areas.

Climatic factors have their influence upon soil formation; but in general the soils correspond closely with the geological formations and are the product of the rapid weathering of the rocks under the influence of rainfall and high temperatures. There are marked differences between the formation of soils under tropical conditions and those of the temperate regions, although the fundamental scientific principles are the same. Such factors as depth of soil, moisture content, drainage, soil structure and tilth, and the nature of the rocks from which they have derived, all have their influence. The interdependence of these several factors must be recognized.

In the wetter areas of the tropics, weathering is much more rapid than in temperate zones, and the biological activities in the soils are speeded up. Under super-humid conditions a dense growth of rain forest exists; but this luxurious cover must not be taken as an index of soil fertility, because as soon as the forest cover has been removed and the land brought into cultivation, there is a rapid fall in fertility. Nitrogen is leached rapidly by the heavy rains, and the forest floor cover of decaying vegetation is rapidly oxidized and lost. It is, indeed, now recognized that in the very wet areas, where there is no well-marked dry season, it is essential for land to be kept under cover of growing vegetation if soil fertility is to be maintained. Tree crops are the best suited for cultivation under these conditions.

Humus is the regulator of good conditions of tilth and of water distribution under the conditions prevailing in the wet tropics, and with perennial crops under a heavy and well-distributed rainfall, green manuring is the most suitable means of maintaining humus. The chief requisite for the successful use of green manures is the availability in the soils of sufficient moisture to ensure decomposition. A green manure crop must, however, be handled with skill so that the carbon and nitrogen cycles are dovetailed with the growth of the main crop.

It may here also be mentioned that one of the striking features of native agricultural systems in the wet tropics is the system of mixed cropping. There is sound justification for this practice.

In the zones of sub-humid climates the sequence of events is somewhat different from those occurring in the super-humid zones. Here there are marked dry seasons when chemical and biological activities are slowed down through inadequate supplies of soil moisture. Green manuring can be used under these conditions only with care, and in areas where the rainfall is poorly distributed their use may indeed be detrimental because of the drain which these green manures make, during their periods of growth, upon the soil moisture. In areas where there are marked contrasts between wet and dry seasons and where high temperatures prevail in the dry periods, it is difficult to maintain under a system of cropping the content of organic matter in the soils; but these soils do not appear to lose fertility so rapidly as the soils in the wetter areas because the losses from leaching are so very much less. In dry areas, much value has been derived from mulching, and in certain places agricultural production has been dependent upon the adoption of this practice.

In soils in the sub-humid zones, the available nitrogen is greater at the end of a long dry and hot period than at the beginning of the drought. Systems of bare fallow between crops are therefore used. This nitrogen is mainly in ammoniacal form; but with remoistening by rain a rapid biological conversion to nitrate takes place and rapid plant-growth results therefrom. One has only to see the rapid flush of grass after the first rains to realize the importance of this store of nitrogen, and where agriculture is practised the aim must be to make the fullest use of it. Weed-growth flourishes in such conditions and causes losses in crops unless promptly and adequately dealt with. It is this weed-growth which peasant cultivators often find it difficult to control.

Soils in the sub-humid zones are also prone to lose crumb structure and to suffer severely from erosion. Examples are to be found in East Africa.

The use of grass leys has been shown in Uganda and elsewhere to improve the crumb structure of the soil, and this system is now extending there and being tried elsewhere. Grass also is a natural good protection against erosion. In short-grass country, overgrazing of stock can, however, easily bring disaster. It has also been found in many parts of the tropics that farm practices may accelerate the destruction of tilth and that cultivation in excess of what is required to control weeds may depress crop yields. Hence the general tendency to reduce cultivations to those which are necessary for the destruction or suppression of weed-growth. It is under sub-humid conditions that the majority of the lands of colonial territories in Africa are found, and while mixed farming is likely to be the best system for peasant production, other systems involving the use of grass leys and fertilizers will have to be worked out for large-scale production.

Water

While some colonial territories have given special attention to the question of water development, there are many others in which much remains to be done. In general, there is a great scarcity of rural water supplies. Populations in certain areas are crowded together because of the limited development of water over a wider area, and in East Africa there is a serious maldistribution of livestock as a consequence of the inadequacy of the supplies of water for such stock.

Irrigation is a recognized part of the agricultural system in the eastern territories, where rice-growing is an old-established occupation; in Malaya, drainage control must be linked with irrigation. This is also the case in British Guiana on the flat coastal lands and in the coastal and internal swamp areas of Sierra Leone. Irrigation is practised in certain of the drier parts of Mauritius and also in Cyprus, where considerable success has recently been achieved with small village irrigation schemes. In areas where rainfall is normally erratic or deficient or where population increases are causing pressure on the land, the further development of irrigation is essential if increased production is to be achieved.

Systems of Agriculture

These range from highly organised systems under estate management, where considerable use of the services of science has been made, to the most primitive of systems of 'shifting cultivation' for the production of subsistence foods. In the West Indies, science can justify a claim to have been responsible for increased yields of sugar of the order of 25–30 per

cent, and in the rubber industry of the Far East, production yields of double or treble those previously obtained from unimproved seedling growths have been achieved since the vegetative propagation of improved strains of rubber has been adopted.

At the same time, it may be safely assumed that productivity could easily be increased by a further 25 per cent in large-scale operations and up to 50 per cent in the smaller holdings from greater efficiency in the methods of husbandry.

At the bottom of the scale is the system of 'shifting cultivation' which is the basic system of subsistence agriculture. This system is still the standard practice of a very large number of the peasant cultivators of Africa and also of other tropical territories in areas where rice cultivation has not been established. These peasant cultivators, in sparsely populated areas, have plenty of land at their disposal, and a system of rotation of land has preference over rotation of crops. This is understandable when land is plentiful and where the people have only the hoe and the axe, in addition to fire, as their aids to the production of their food requirements. They may choose their lands with care, and they may be skilled in the choice of plant indicators of good soils; but their operations are restricted by the tools at their disposal, by the fall in soil fertility which follows the first year of cultivation and, most of all, by their inability to deal with the luxuriant weed-growth, which becomes really troublesome in the second season. It is this weed-growth which is generally the controlling factor in shifting cultivation in the wet tropics.

In some parts of Africa there have been natural evolutions from the primitive system of 'shifting cultivation' to a more settled form of continuing production, especially where cash crops have been established; but in some places it has been necessary to arrange for new settlements because of the low fertility to which the land has been reduced. In such cases, it is not unknown for reluctance to be shown to the abandonment of land occupied by the tribal group in favour of a movement to new sites, because of the beliefs of the people; and this has been even more marked when the occupation of the new land has been conditioned by arrangements for its proper use.

Advances in tropical agricultural systems have, however, in general been most rapid under European management, or where there has been a mingling of large-scale and peasant production. The progress made in the past twenty years has been considerable; but the needs of the next decade will necessitate a revolution in methods of production, especially if the standards of life of the colonial peoples are to be markedly advanced. The hoe system of agriculture will have to give place to other methods; and the introduction of mechanized aids and of fertilizers is inevitable.

Estate cultivations have made increasing use of fertilizers; but the experimental work with fertilizers has been mainly confined to the requirements of the cash or export crops. Little has been done where food crops are concerned except in regard to rice, largely because of the low unit monetary values of these crops. Some useful work has, however, been done in Northern Nigeria and in isolated instances elsewhere; but a wide scheme of fertilizer trials, planned in accordance with the most modern techniques for field experiments, has recently been started in East Africa.

Use of Livestock

Agricultural progress in Western countries has been linked with the use that has been made of livestock, and this has led to the development of important animal industries. In the colonial territories livestock industries are but little developed. It is true that considerable use is made of buffaloes and cattle for draught purposes, as well as in connexion with rice cultivation in the Eastern colonial territories and also for the production of milk and milk products. An important livestock industry also is developing in the highlands of Kenya, where European strains, especially when crossed with selected animals from the native stock, thrive satisfactorily, and where a number of co-operative creameries have been established. Similarly, European strains form the basis of the livestock in the West Indian colonies, and a thriving dairy industry has been developed in Jamaica since the establishment some seven years ago of a milk condensary.

This use of European strains of livestock in tropical areas cannot, however, be general, and reliance has to be placed on the improvement of the native breeds. The heat-regulating mechanism of European cattle is adapted to life in temperate climates, and the high ranges of atmospheric temperatures and humidity, especially where there is a low rate of air movement, cause adverse physiological reactions under tropical conditions. The stock have higher body temperatures, higher respiration-rates and a change in the pulse-rate. European breeds are not suited to those areas in colonial territories where high average temperatures and high humidity prevail, and under these conditions they can only be kept in full productivity when they are maintained under artificial conditions of controlled temperatures, as they were before the War in some special dairies in Singapore. It is only at the higher altitudes where temperate conditions prevail, or in the island territories where air movements are considerable, that European stock can be satisfactorily maintained if the higher plane of nutrition required is available. Even in these conditions it is necessary to provide a sufficiency of shade and to see that the stock are not subjected to the full blaze of the tropical sun between the hours of 10 a.m. and 4 p.m. The crossing of European stock with Indian or the indigenous breeds of Africa has been fairly widely practised. This system can, however, only be used in restricted areas and, in general, selection from the indigenous stock will be the soundest policy.

So far, the livestock of the colonial territories of Africa have been little used in agriculture. The herds are grazed on the natural pastures and move over fairly wide ranges from area to area according to the seasons and the nature of the herbage. Their owners are reluctant to sell them, and agriculturists frequently have difficulty in acquiring stock for their farm needs.

Where there is overstocking, soil erosion and land deterioration can be traced directly to the damaging effects of overgrazing and excessive trampling of the land; but experimental trials have shown that where controlled grazing is practised and where stock numbers are limited to the carrying capacity of the land, considerable improvements can be effected.

In some colonial territories there has been an extension of the use of livestock for the manuring of agricultural land, for the production of dairy products, for the conversion of farm wastes and for purposes of

draught. In African territories, however, numbers are placed before quality because of the fear of losses from disease and because the social status of their owners in the community is judged by the number of stock owned. The problem of livestock in Africa is full of difficulties; but it must be tackled resolutely and with imagination if the present damage to land is to be checked, and if an animal industry of full value to the inhabitants of the territories concerned and to the world in general is to be established.

Livestock management by colonial peoples is still very backward even where mixed husbandry or dairying has been established; but it is general to find that peasant farmers with livestock are better off and live at higher standards than do those who possess no livestock.

Crop Varieties

Some reference has already been made to the increased yields which have been secured from the use of improved seed or planting material. In no sphere of the application of science to tropical agriculture has more progress been made.

Sugar cultivations now depend almost entirely upon the growth of improved strains of seedling varieties. Cotton production also requires the continuing production of new types suited to the particular conditions under which they are grown. Rubber growing has been transformed by the selection of high-yielding strains which, when proved, have been propagated vegetatively or planted in special isolated gardens for the production of self-fertilized seed. Similar progress has been made with coffee, cacao and, to a lesser degree, with tea, while the successful cultivation of tung depends entirely upon selection work. Many other examples could be quoted.

In certain areas, breeding work has been done with tropical food crops; but the progress in this field has not been so pronounced as could have been hoped for. The genetics of the genus *Musa*, to which the banana belongs, has received considerable attention at the Imperial College of Tropical Agriculture in Trinidad and also in Jamaica, where large numbers of seedlings have been produced. None of these, as yet, fully meets the commercial requirements of the trade, and a further search for new breeding material is shortly to be made. In Barbados, all sweet potatoes now grown are of seedling origin, and the yields are markedly in excess of those obtained from the earlier standard varieties. Similarly, strains of cassava which are improvements on the earlier types have also been evolved. Marked improvements have been made with rice in Ceylon, in Malaya and in British Guiana. The millets have not, so far, received the attention that should have been given to them, and it is hoped that early steps will be taken to establish special stations in Africa for meeting this need.

Pests and Diseases

In the past, the human diseases of the tropics and the pests and diseases of crops and stock controlled output. Malaria is of frequent occurrence, and its debilitating effects are still considerable. The lessons of certain operations in the Second World War have proved that a large measure of control over malaria is possible, and the value of *D.D.T.* in the control of mosquitoes in houses and villages has already been successfully demonstrated in British Guiana, Uganda, Mauritius and elsewhere, while a large-scale experiment in the Karpas peninsula of Cyprus has given such satisfactory results as to warrant wider trials in that Colony and to the planning of an all-island campaign against malarial-carrying mosquitoes in Mauritius.

The tsetse still holds under its control vast areas of Africa, and trypanosomiasis in man and in stock is still a controlling factor in certain areas. In Tanganyika, it is estimated that two-thirds of the total land area is infested by different species of tsetse flies; vast stretches of that territory are, in consequence, devoid of population. Much research work has been done on tsetse control and some advances have been made.

Among stock diseases, rinderpest, East Coast fever, pleuro-pneumonia and intestinal parasites have to be contended with. Progress has certainly been made by the veterinarians; but rinderpest is still a factor which cannot be regarded with equanimity in the African territories.

Locusts still cause damage to crops from time to time in Africa; but marked advances have been made in our knowledge of the bionomics of the three species of locusts with which colonial territories in that continent have still to contend. The application of control measures based upon this knowledge is steadily continuing, but final success cannot yet be claimed.

Crop pests account for losses, and in certain areas they are a controlling factor. Those of cotton have received special attention, and the work of the entomologists of the Empire Cotton Growing Corporation has been outstanding. A considerable knowledge has been accumulated and this enables an assessment to be made with a fair measure of accuracy of the areas in which cotton cultivation can be extended and those in which such extension would at present be unwise. Control of certain pests of cotton and of several diseases has been achieved by the breeding of resistant strains, although it is still estimated that if the lygus pest in Uganda were controlled, output would be increased by 50 per cent. Similarly, there are still considerable losses during storage, especially in food crops or grains, and these are now under special investigation in West Africa.

Among plant diseases mention should be made of the witches' broom of cacao which has had devastating effects in Trinidad and South America, the swollen shoot virus disease of cacao in West Africa, the die-back of cloves in Zanzibar, the mosaic disease of cassava, the Panama disease of bananas in the West Indies and the bunchy top disease of bananas and manila hemp in the East. The virus disease of cacao has already caused the loss of nearly one-third of cacao production in the Gold Coast. A special West African Cacao Research Institute has been established [see *Nature*, January 24, p. 117] and very considerable progress has been made. It is, however, unlikely that the disease will be finally defeated until new types immune or resistant to the virus have been found. Further expeditions in search of new strains of cacao from South America are contemplated and, in order to assist banana producers, a scientific expedition to collect wild species of *Musa* from south-east Asia is in process of being arranged.

Marketing Arrangements

Marketing arrangements and the prices of commodities have their place of importance in the efforts of all producers and agriculturists, as well as others. Price fluctuations often affect total production, and frequently the productivity of individual producers or groups of producers. When prices are low, agri-

culturists tend to cut out maintenance works, and efficiency suffers. The fluctuations and the general trend of low prices for primary products between the two World Wars were not without their effect upon efficiency of production in the colonial territories.

The Second World War saw the introduction of bulk buying and selling of certain colonial commodities, and this system has introduced a system of agreements under which prices have been fixed by negotiation.

The value of such a system was appreciated by colonial producers, as it enabled them to plan their production ahead with some measure of confidence. Peasant producers have also benefited from, and have generally recognized the value of, the systems of price fixing which were adopted. There have, however, been fears that these arrangements could not be continued, and at the present moment further consideration is being given to the matter. Commodity marketing organisations are being continued, and steps are being taken to build up price equalization funds so that when prices fall the producers will not suffer unduly. Contracts for purchase of some commodities now include provision for (*a*) equipment replacement, (*b*) the building up of price equalization funds, and (*c*) expenditure on welfare amenities for the labourers employed.

The above arrangements relate to export commodities, and they should have a stabilizing and encouraging effect on production; but there are some who still contend that the contract periods are of too short a duration. Production for home consumption in the Colonies, especially of foodstuffs, would be stimulated if price-regulating methods similar to those contemplated under the recent United Kingdom Agriculture Act could be brought into effect.

Social Organisation

In the West Indies and some of the older Colonies, lands have from the first been held on forms of tenure and title similar to those prevailing in the United Kingdom, and social organisation has followed, with adaptations, the English pattern. In others, the forms of tenure have originated in indigenous customs which were an integral part of the social structure. In the African territories and also in some others, this structure, which is based upon the village, is built upon communities. Rights to particular plots of land are often recognized; but these rights are limited to the period of occupation, restricted as to succession and qualified by membership of a kinship, clan or other group. These plots are usually small in size, and the community interest generally prevails so far as land is concerned. This is usually not the case in respect of the produce from the land.

Customary rights have undergone, and still are undergoing, a rapid process of change as the result of economic influences. The expansion of education, as well as the development of urban areas, and of mining, have had their effects. Introduction of new types of crops and of new methods of agriculture also have brought about important changes. The introduction of permanent tree crops such as cacao and coffee, for example, has resulted in a firm growth and expansion of the conception of ownership as against the previously held conception of a collective right in land derived from indigenous custom, and changes have been accelerated by the necessity for adjustment to the needs of modern economy of production and marketing. In some territories defined native reserves have been established, and in others there are to be found land tenures based upon the indigenous customs alongside those which have been introduced from elsewhere for alienated lands.

It is impossible to deal here, however, with the varying systems of land tenure which are found in colonial territories, to the tribal restraints which are sometimes imposed upon enterprise and initiative, or to discuss the strains and stresses which are resulting from the spread of education.

Productivity of land, however, depends as much upon sound systems of land tenure as upon improved agricultural practices, and any policy of development must increase the range of land matters and social issues to which colonial administrations will have to give urgent attention. It would seem that a solution of the social issues involved must lie in finding a balance between the advantages and disadvantages of the traditions of the past, the customs of the present and the needs of the future. Bold experiments may have to be made.

Conclusion

I have attempted, briefly, to review those factors which affect production in colonial agriculture. They are many and varied, and several of them are interdependent. In the early stages of colonial endeavour empirical measures sufficed, but these have gradually given place to methods which are being evolved on an ever-widening basis of knowledge. The man of science and the administrator are equally concerned, and a closely knit partnership between them must be established for the combined operations which are required.

Science has an important part to play. All research work must be planned in such a way that it is relevant to the objectives in view, and the utilization of this knowledge must be regarded as a duty of the administrative machine.

In agriculture, the scientific research worker should have full and frequent contact with production at all stages and with the persons engaged in that production. Without this contact, research is liable to become sterile and ineffective. Research organisations for specific industries, when they can be afforded, have their value, as they do ensure that the results of their work are translated quickly into practice. When, however, research work is planned on a wider basis, steps must be taken to ensure that it is not divorced from those charged with helping the advancement of the cultivators of the land. The chain must be complete to be effective.

Equally, the human side must not be disregarded. In many respects, it is the more important, as support for change or advancement can only be secured when the peoples concerned are convinced that such change will be for their advantage and worth the effort. Education has an important part to play here.

To the majority of the colonial peoples, agriculture is the foundation of their lives, their well-being and their hopes. With good will and understanding and with proper organisation, agricultural production can make great strides forward, but the traditions and customs of the colonial peoples must always be regarded sympathetically and with understanding. If the objective of greater production is made clear, enthusiasm aroused and willing co-operation secured, progress is certain. There are hazards which have to be surmounted, but with the aid of science, these will be overcome, and in future years they may be regarded as having been only the 'whistle points' along the track of development and progress.

AIRCRAFT ATTACK ON LOCUSTS

By Dr. D. L. GUNN

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THE most commonly effective method of destroying locusts at present is to poison the hoppers (nymphs) before they can fly. Some kind of bait, such as moistened bran, which is eaten in preference to other food, is poisoned with benzene hexachloride (hexachlorocyclohexane, 'Gammexane', 'Benhex') and is scattered thinly in front of the advancing bands. For an infestation of any magnitude, this requires a large labour force. In some parts of the world, even in Africa, there is a severe shortage of labour, so that it is increasingly difficult to get adequate supplies of casual seasonal workers. When a widespread plague occurs, it is sometimes necessary to call upon the army to do much of the work. In addition, the work must often be done in areas which are so far from sources of supply of food and even water that the cost of transport becomes considerable. It is therefore not surprising that attention has been given to the use of machinery to replace much of the unskilled labour.

The aeroplane is the machine which is most independent of difficulties of terrain, such as occur in the great spaces of Africa. One therefore naturally thinks of the aeroplane as the primary weapon for coping with inaccessibility of locusts and with mobility of migrating swarms; such a weapon would be especially valuable if the adults could be attacked before breeding. A number of attempts have been made during the past decade or so to use aircraft for attacking various kinds of insects; in few cases does it appear that these have led to the establishment of routine methods. The exceptions are mostly concerned with dusting or spraying particular places, so that a small airstrip can be cleared very close by, and light aircraft can attack day after day and year after year.

Much more difficult problems arise when the target is as mobile as a swarm of locusts. From time to time, aircraft trials against locusts have been made in various countries, usually with much optimism but with too little scientific background research to enable much to be learnt. These sporadic and disconnected trials have received newspaper publicity out of proportion to their real value. We have therefore set out systematically to find whether aircraft methods are applicable to locust destruction, and to work out where and when they may compete in effectiveness and in cost with other methods. This article is a summary of as yet unpublished material obtained in work initiated by the Anti-Locust Research Centre on behalf of the Colonial Office, and carried out in co-operation with the Royal Air Force, the Middle East Anti-Locust Unit, the East African Anti-Locust Directorate, the International Red Locust Control Organisation, the South African Air Force and the Union Department of Agriculture (Locust Control and Research Section), the Colonial Office Insecticide Flight, and perhaps most important of all, the Ministry of Supply, especially the Chemical Defence Experimental Station at Porton, Wiltshire.

The first experiments were carried out in 1944, by the Anti-Locust Flight (R.A.F. and S.A.A.F.) and Dr. J. S. Kennedy in the Kenya Highlands[1]. It was found that the most effective contact locusticide available was dinitro-*ortho*-cresol[2] (*D.N.O.C.*), and a dust containing 14 per cent of this was scattered from Avro Anson (Mark I) aircraft on to the locusts (*Schistocerca gregaria* Forsk.). The apparatus and methods were derived from the Russians, with whom the Flight had been preparing the work in Persia. It was found that the effectiveness of the dust varied enormously, apparently with atmospheric humidity, so that in wet conditions a high mortality occurred with less than 7 lb. of dinitro-*ortho*-cresol dust per acre, while in dry conditions there was a low mortality with more than 50 lb. per acre. The aircraft had to fly very low—below the tops of the occasional trees—to get the dust down relatively evenly in the right place, so that the swaths were narrow (7–25 yards), and the locusts were often disturbed and avoided the dust. The hastily improvised apparatus was heavy, it increased the air resistance of the aircraft, and it required a man in the aircraft to operate it, so that the useful load carried was only 650 lb.; consequently a single load would cover only twenty acres or so at a middling dosage, and even that took rather a long time. The mobility of a swarm caused very great difficulties, for it had to be located, its limits found, markers placed to guide the aircraft on each run, and the attack had to be completed between the time when the swarm went to roost in the evening and its departure a few hours after daybreak next morning. Further research was thus required on the insecticide and its distribution, on locust behaviour and on field organisation and methods.

Dr. Kennedy then returned to England, to the Ministry of Supply's laboratory at Porton, and began laboratory studies on the spraying of settled and of flying locusts with contact poisons, in close relation to his field experience[3]. These investigations covered the study of the dose required to kill an individual locust, the amount of spray which a locust would pick up under various conditions at rest and in flight, the effectiveness of poison falling on various parts of the body and the area dosage required in the field; they were, in fact, partly fundamental investigations on the principles of insecticide application, and have since been continued by others at Porton. A 5 per cent solution of *D.D.T.* was found to be ineffective at 9 gal./acre, while a 2½ per cent solution of dinitro-*ortho*-cresol in a mixture of aliphatic fractions of petroleum produced 50 per cent mortality at about 1½ gal./acre. Benzene hexachloride was less effective and slower in its contact action, which contrasts markedly with its superiority as a stomach poison for locusts.

By August 1945, a programme of spraying trials against locusts in Kenya had been prepared at Porton. The methods recommended, instead of being hindered by all except a narrow range of air conditions, were to take advantage of the wind in a calculated way so as to produce a wide and predictable swath. The solution was to be released from a single simple orifice placed outside the wash of the propellers, so that it broke up into drops in comparatively constant conditions; with a solution of constant physical properties, the drop spectrum could be determined and the way in which the drops would fall in ideal conditions could be calculated; inferences could then be made for applying the spray in real conditions. Methods of determining the proportion of the poison reaching the ground were worked out.

In early 1945, I was seconded from the University of Birmingham to the Anti-Locust Research Centre

and joined the Anti-Locust Flight in Kenya, then commanded by Major J. G. Strunck. We proceeded to investigate the behaviour of the desert locust in relation to aircraft spraying[4,5]. By the time the Porton programme reached us, we were sufficiently familiar with locust behaviour and with methods of searching for swarms. Using Baltimore aircraft of the Anti-Malaria Flight of the R.A.F. under Flight-Lieut. E. C. Jaques, we then carried out trials against both settled and flying locusts[6]. These aircraft could carry 300 gal. of insecticide in bomb-bay overload tanks, but had a rather high cruising speed and were expensive to fly and maintain. The determination of mortality was difficult and unreliable, and the experiments against roosting locusts revealed a number of snags; but they substantially confirmed the value of the poison and of the methods prescribed by Porton. It was evident, however, that for aircraft to be used economically the poison would have to be much stronger, so that a smaller area dosage could be used to give a complete mortality. It was also amply confirmed that the search for roosting swarms, their delimitation and their demarcation, were usually likely to be too difficult and slow to enable aircraft attack on roosting locusts to be widely applicable. Preliminary tests were also made on flying swarms, and sufficient was learnt to encourage further research at Porton.

During the following year, considerable improvements were made in the apparatus and in the insecticide. A solution of 20 per cent dinitro-*ortho*-cresol was prepared in a mixture of aromatic extracts of petroleum which had the required physical characteristics and a toxicity proportionately greater than the earlier 2½ per cent solution. When an opportunity occurred in June 1947 to carry out an experimental campaign for the International Red Locust Control Organisation, we had the necessary information to decide what we could do.

A rapid investigation of the local conditions in the affected area, the Rukwa Valley of south-west Tanganyika, showed that the terrain was exceptionally favourable for attacking the roosting locusts (*Nomadacris septemfasciata* Serv.). Accordingly, a joint effort was arranged between the Governments of the Union of South Africa and the United Kingdom, and spraying was begun at the end of August. It was not possible to get any of the new dinitro-*ortho*-cresol solution to those remote parts so quickly, and benzene hexachloride solution (2 per cent gamma isomer) was at first used, with inadequate results. When the complete unit was assembled, it consisted of six aircraft under the command of Capt. Peter Daphne, four of them being S.A.A.F. Avro Ansons (Mark IX) and two Colonial Office Ansons (Mark XIX) with the most up-to-date Porton fittings; the South African part of the scientific party was led by Mr. H. A. F. Lea. The dinitro-*ortho*-cresol spraying was dramatically successful[7]. In one operation, a mortality of 98 per cent was obtained at a dosage of ¼ gal./acre. In another, nearly two square miles were 95 per cent cleared of locusts at a dosage of 0·7 gal./acre; six aircraft made one sortie each and covered the ground at a rate of nearly 12 acres per minute from start to finish. At just over 1 gallon per acre, the dinitro-*ortho*-cresol produced practically 100 per cent mortality. In the last twelve days, an area of 11,000 acres of the worst infested part of the Milepa outbreak centre was 95 per cent cleared of locusts by spraying selected patches totalling 3,300 acres. It was afterwards stated by the director of the International Red Locust Control Service, M. Hans Brédo, that a substantial contribution had been made towards checking the threatened outbreak from this area.

Several lessons were learnt from this campaign. It had clearly been well worth while to base it upon equipment, material and methods which had been elaborated in patient research in Britain, for even in the heat and haste of the campaign, we were able to discover what was happening and make calculated adjustments in the methods. This time, the problem of the assessment of mortality from poisoning by dinitro-*ortho*-cresol scarcely arose, for complete clearance was achieved in the first few trials. All we had to do then was to reduce the area-dosage until a few survivors could be found. The technique of demarcation was greatly improved, so that it became possible for the airman to use his maximum skill in making half-mile spraying runs every 1½ minutes; to allow this, the markers had to move a measured distance of between 50 and 200 yards in only 35 sec. The reconnaissance, delimitation and demarcation could not have been carried out but for the very favourable circumstances; the terrain, which was very flat; the vegetation, which was patchy and comparatively easily penetrated; and the locust behaviour, which was quite unusual, for the swarms ceased to move about just after the dinitro-*ortho*-cresol reached the Rukwa. The costs of the various items in the campaign are not yet fully known, but preliminary information indicates that if full use is made of the aircraft over a long enough period, their cost is of the same order of magnitude as that of the insecticide. It is therefore important to make the insecticide as concentrated as possible, so long as the dosage does not become too small to spread evenly, to avoid losses from evaporation during spraying, and to develop methods of avoiding errors. For example, the use of a radio-altimeter in the aircraft would make it easier to fly at the correct height without the need for the two men on the ground to keep measuring it and reporting to the pilot.

Although it has thus been shown that aircraft can be used to destroy roosting adult locusts under suitable conditions, this method is unlikely to be widely used if ground machines can do it just as well and more cheaply. In conditions of terrain which allow reconnaissance, delimitation and demarcation to be done so effectively, it seems likely that such ground machinery could spray the locusts without the aid of aircraft. Accordingly a prototype machine is being constructed in Britain for this purpose. The problem remains of finding a type of vehicle which can carry it over rough or wet ground and through shallow water and mud. Even the 'jeep', with its four-wheel drive and extra-low-gear-box, which is the most suitable vehicle for locust reconnaissance across country, cannot operate in deep soft mud. What is required is a vehicle which can do this and can carry a couple of tons of machinery and poison. Such a vehicle would have numerous uses in Africa, where in many places movement of normal vehicles has to stop during wet weather.

Attack on roosting adult locusts, whether by aircraft or by ground machines, is limited to the period during which the locusts remain settled. During hot weather, this may be very short; one of the swarms which we attempted to attack in the Rukwa Valley actually flew away before sunrise. Once they are in flight, aircraft are the only machines mobile enough to attack them, and the whole of the daylight hours may be available for this method. Since adult locusts

cannot leave an outbreak area or invade a cultivated one without flying, aircraft methods of attacking them in flight are urgently required, especially in view of the large agricultural developments to which Britain is now committed in East and Central Africa.

For attacking flying swarms, the aerial curtain spray method was on the programme for trial in Kenya in 1945. It consists essentially in laying spray at right angles to the direction of flight, irrespective of wind. The spray from a single run would be largely wasted in sub-lethal doses, so the main problem is how to make repeated runs in the moving air in such a way that the sheet from each run is laid immediately over the preceding one, and the curtain so formed continuously contains the minimum necessary amount of poison. It was shown in 1945 that locusts could be killed in this way, and certain deficiencies were discovered[6]. Since then, advances have been made at Porton in the rather elaborate calculations of what happens to a falling curtain of this sort in relation to a swarm flying through it. Considerable improvements have also been made in the special aircraft equipment necessary, and increased knowledge has been gained of the amount and toxicity of spray droplets of different sizes picked up by locusts in flight[7]. Field trials of aerial curtain spraying are planned for this year.

In conclusion, it should be made clear that no one technique of locust control is likely to meet all requirements. It may ultimately be possible to prevent the occurrence of plagues of some species by changes in the ecology of the outbreak centres. In the meantime, constant vigilance is required over gregarious areas, and insecticides will have to be used by a wide enough variety of methods to suit all circumstances.

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[2] Nolte, M. C. I., Sci. Bull. Dept. Agric. S. Afr., Pretoria, No. 232 (1941).
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[4] Gunn, D. L., Perry, F. C., Seymour, W. G., Telford, T. M., Wright, E. N., and Yeo, D., Anti-Locust Bull., London (1948, awaiting publication).
[5] Gunn, D. L., Perry, F. C., Seymour, W. G., Telford, T. M., Wright, E. N., and Yeo, D., *Nature*, **156**, 628 (1945).
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[7] Gunn, D. L., Lea, H. A. F., Botha, D. H., Callaway, S., Clackson, J. R., Immelman, A., Taljaard, J. J., and Ward, J. (1948, Govt. Press, Pretoria; in the press).

NEWS and VIEWS

Mathematics at University College, Leicester: Prof. R. L. Goodstein

An interesting appointment has been made at Leicester to the newly created chair of mathematics. Dr. R. L. Goodstein, of St. Paul's School and Magdalene College, Cambridge, has been a lecturer at Reading since 1935. He has no less extensive a knowledge of mathematics, as commonly understood, than any of his contemporaries; but it was Wittgenstein who excited and inspired him, and he has made his reputation and won his position by original work on the foundations of mathematics. It is half a century since Russell first insisted that investigation into the principles of mathematics was a task for expert mathematicians, not for philosophers, but hitherto the subject has been one in which a mathematician could not take more than an amateur interest without endangering his professional status. A bad tradition has been shattered at last.

Institute of Metals (Platinum) Medal: Dr. R. C. Stanley

The Institute of Metals (Platinum) Medal for 1948 has been awarded to Dr. Robert Crooks Stanley, chairman and president of the International Nickel Company of Canada, Ltd., in recognition of his outstanding services to the non-ferrous metal industries. Dr. Stanley, who was born at Little Falls, New Jersey, in 1876, was educated at the Stevens Institute of Technology and Columbia University. On the organisation of the original International Nickel Company in 1902, Dr. Stanley became assistant superintendent of the Camden (N.J.) Works, and eventually superintendent; in 1904 he was transferred to Bayonne as assistant general superintendent of the Orford Copper Co. At both plants he was responsible for a complete modernization programme. 'Monel', the white alloy of nickel and copper, owes its discovery in 1905 to Dr. Stanley, who conceived and developed the process for producing the alloy direct from ore without separating the nickel and copper. In 1917 he was elected a director, and in 1918 vice-president in charge of all operations of the International Nickel Company. When he became president in 1922, the nickel industry was at its lowest ebb, and one of his initial efforts was the formation of a Development and Research Division, through which thousands of commercial peace-time applications for nickel were established. Thus began probably the most vital phase of growth in the nickel industry. Following the acquisition of the Mond Nickel Company, Ltd., Dr. Stanley continued as president and became chairman in 1937. In both the First and Second World Wars, Dr. Stanley was responsible for greatly increasing nickel production for its many vital war uses.

University Halls of Residence

The Report of a Commission appointed by the Committee of Vice-Chancellors and Principals of Great Britain and Ireland on "The Planning of University Halls of Residence" has recently been published (Oxford: Clarendon Press, 1948. 6*s*.). The chairman of the Commission was Dr. Keith Murray, rector of Lincoln College, Oxford, and the secretary, Prof. C. M. Attlee, formerly professor of education in University College, Nottingham. The Commission visited the most important universities and colleges which have residential halls or hostels (forty-seven altogether), and interviewed a number of authoritative witnesses. The investigation was thorough, so the Report is exhaustive, dealing with size and layout of residential halls, corridors and staircases, optimum size, finance and costs, administration and management. One appendix deals with the floor areas of all constituent rooms of a hall to accommodate 150 students and staff. Another lists equipment required, including furniture, crockery, cutlery, linen and domestic materials. A short bibliography is appended.

Care has been taken to consider the need for quiet and for adequate and suitable heating and lighting.

The Commission emphasizes the need for a good library, though it will probably inevitably be a small one. The need for carefully considered medical arrangements, including a sick-bay for students, is fully discussed. A warden in charge is recommended; but a vice-warden is not considered essential unless the hall accommodates more than 150 students. Members of the university or college staff should not be admitted as residents unless they are prepared to assist in the creation of an academic and friendly atmosphere. Domestic administration should be in the hands of a bursar; it should not be left to the warden. General opinion favoured 100–150 as the most satisfactory number of students; though there are arguments for smaller units, mainly on grounds of congeniality.

The Report will prove of considerable value to academic and other authorities who are considering constructing halls of residence, and those who are interested in halls already in existence will read it with profit. Literary quotations in a factual report of this sort seem out of place; in fact, that introducing the index is fatuous.

Amalgamation of Instrument Makers: Hilger and Watts, Ltd.

THE well-known instrument makers Messrs E. R. Watts and Son, Ltd., and Adam Hilger, Ltd., are being formed into one company registered as Hilger and Watts, Ltd. Watts was founded in 1856 and has specialized in the manufacture of surveying and engineers' measuring instruments, while Hilger, started in 1874, has built up a world reputation for instruments for research and industry. The products of the two firms are complementary to some extent, and the instruments developed by Hilger for chemical, biological and medical research are closely related with the products of James Swift and Son, Ltd., microscope makers, who are a subsidiary of Watts. The resources for research which have been at the service of Hilger and Watts respectively, and to which their success has been largely due, will be combined. The board of directors of the new Company is an amalgamation of the boards of Hilger and Watts, namely, G. A. Whipple, who has been managing director of Watts and Hilger since 1939 and 1946 respectively (chairman and managing director); F. Twyman (technical adviser); Dr. A. C. Menzies (controller of research); D. R. Stanley (controller of sales); V. W. H. Towns (technical controller); R. H. Watts (assistant controller of sales). Hilger and Watts, Ltd., will employ 1,300 people in the six existing factories. A new factory in the Greater London area has been planned and approved.

Export Organisation for British Scientific Instruments

SCIENTIFIC EXPORTS (GREAT BRITAIN), LTD., Buckingham House, Buckingham Street, London, W.C.2, is a co-operative marketing organisation set up by a group of British firms specializing in the production of high-quality scientific and surgical equipment. Through its world-wide agency, customers will be able to obtain from one source a very wide range of the finest equipment available. For circulation abroad, the organisation is issuing an illustrated bulletin, the first number of the technical series of which has recently been received. The bulletin is intended to supply regular and up-to-date information of progress in the above fields, and will include detailed descriptions of products, techniques, and developments in the spheres covered by the manufacturing members of the group of manufacturers involved. The members introduced in the first number are Allen and Hanburys, Ltd., founded in 1715 and famous for their pharmaceutical products; Baird and Tatlock (London), Ltd., laboratory suppliers for more than fifty years; W. Edwards and Co. (London), Ltd., high-vacuum specialists; Adam Hilger, Ltd., founded in 1874 and specialists in spectroscopes and astronomical instruments; Hopkins and Williams, Ltd., who have been engaged in the manufacture of fine chemicals for nearly a century; W. Watson and Sons, Ltd., founded in 1837 and chiefly noted for microscopes; and E. R. Watts and Son, Ltd., established in 1857, and makers of theodolites, levels and other surveying equipment.

Animal Health in British Guiana

A REPORT on British Guiana, by Prof. W. C. Miller, forming part of a survey of animal husbandry, feeding, management and veterinary services in the West Indies, has been issued as Bulletin 19A of the series "Development and Welfare in the West Indies" (Bridgetown: Advocate Pub. Co., Ltd. 10 cents). Reviewing the general position of livestock, Prof. Miller points out that the running of estate dairies in the coastal belt has great potentialities from the point of view of improved human nutrition and of the general improvement of the livestock reservoir of the Colony, and suggestions are included both for a Government ranch and for a breeding policy for two types of herds. Stress is laid on the great potential asset of the cattle ranches; and in addition to proposals for changing the character of the breeding stock in the hinterlands, the report discusses transport of meat by air and the establishment of an abattoir. Dealing with peasant-owned livestock, Prof. Miller regards prospects for dairying as reasonably good; but now that extension of livestock production has been started, more adequate provision for control of disease and for improving animal health by the formation of a properly constituted veterinary service is imperative. In Prof. Miller's opinion, the minimum effective service would consist of one deputy director of agriculture, stationed in Georgetown, with two senior veterinary officers, one on the coastlands and the other in the Rupununi; two veterinary officers, one on the coast and the other available for emergency work; one senior and two other animal husbandry officers, one of whom would be stationed in the Rupununi or other part of the hinterland. Technical staff would also be required in the veterinary laboratory now being equipped. There is already more than sufficient work to keep such a staff fully employed, and basic agricultural education is also required at all levels. In particular, Prof. Miller directs attention to the question of scholarships for higher training in veterinary science and animal husbandry for locally born persons, and to the desirability of arrangements for periods of study-leave for officers already in the service to be spent at institutes investigating associated or cognate problems.

Lundy Field Society

THE first annual report of the Lundy Field Society, Lundy Island, shows that the year's working was more one of growth, exploration and experiment than of

achievement. The total membership is now 127, of whom thirty-four have visited and worked on Lundy during the season. Most of the work already attempted has been concerned with the building up of ornithological records, although the difficulty of maintaining a Heligoland-type trap on Lundy has meant that work on birds so far has been mainly carried out by observation. The report contains a full list of the species recorded and also an account of various ecological surveys begun in different terrestrial and freshwater habitats on the island.

National Museums of Ceylon

THE Administration Report of the Director of National Museums for 1946 (Ceylon Government Press, Colombo, 1947) gives news of the commencement of museum reconstruction in Ceylon. The Colombo Museum was derequisitioned by the military authorities in January 1946; but although the Public Works Department had the building under repair, it was not until the following July that any part of it was fit for the return of some of the Museum's collections. In spite of this and other difficulties, however, it is recorded that when part of the building was reopened there were 22,128 visitors to it between December 20 and 30 of the same year. Reference is made in this section of the report to the requisitioning of show cases by the military authorities in 1942; of the 262 taken over, only 85 were returned fit for use. To replace those lost, orders have been placed with the Crown Agents to the sum of Rs. 91,950, while a further sum of Rs. 41,850 was assigned to the Government Factory Engineer "for building show cases locally, with what was left of the glass that was removed from the original show cases at the time of requisitioning". One is left wondering to what use military authority could have put museum exhibition cases that they suffered so much damage. A new south wing to the Kandy Museum is under construction, and what is left of the King's Palace will be converted into a part of the same Museum. A special strong room will house the Sinhala Regalia. The Ratnapura Museum was reopened to the public in April 1946, while the Jaffna Museum was expected to reopen in July 1947. Under the different museum headings, the report includes long lists of acquisitions made during the year under review.

Standardization of Micro-film Technique

BRITISH STANDARD SPECIFICATION 1371 : 1947 for microfilm, readers and reels has been produced in co-operation with the American Standards Association's Committee, and American standards about to be published will provide equivalents to B.S. 1371, so that microfilms made in Great Britain should be capable of satisfactory projection on a reader made in the Commonwealth or in the United States and vice versa. The specification covers 16 mm. and 35 mm. microfilm readers and reels for processed microfilm, each in a separate section. The first section specifies the stock to be used, dimensions, method of winding, the leader trailer and title frame, as well as the arrangement of images and correct sequence of pages for convenient reproduction. Essential dimensions for microfilm readers are specified in the next section, as well as other features for satisfactory reproduction, including the type of lens and magnification and the limiting temperature for the film in the gate, a method of measuring which is described in an appendix. Dimensions and features of reels for processed microfilm are specified in the third section. Standardization along the lines indicated in this specification and the three forthcoming American standards should materially assist the satisfactory use of microfilm and its extension to further fields.

Growth and Nature of Egyptology

AT long last the University of Cambridge has a chair of Egyptology, and Prof. S. R. K. Glanville's inaugural address has been published (London : Camb. Univ. Press. Pp. 37. 1*s.* 6*d.* net). The subject has for some time been taught officially in London, Oxford, Liverpool and Manchester; but although so late in the creation of a chair, Prof. Glanville directs attention to three eminent Cambridge men—C. W. Goodwin, E. A. Wallis Budge and Sir Herbert Thompson—who played a big part in the building up of the subject. Actually, it is owing to the generosity of the last of this trio that the creation of the present chair has been made possible. Prof. Glanville continues with a brief survey of the subject under the three headings: monuments, antiquities and writings. He concludes with a strong plea that Egyptology, although not of immediate use like engineering and medicine, yet has its place in the teaching of a great university; he ends with a quotation from Housman: "The pursuit of knowledge, like the pursuit of righteousness, is part of man's duty to himself".

Society of Engineers: Awards

AT the inaugural meeting for 1948 of the Society of Engineers (Inc.), the first award was made of the Simms Gold Medal, established under a bequest by the late F. R. Simms, for "a paper or lecture describing a new technical discovery, an outstanding invention, or the results of useful research work". The medal was presented to Mr. J. G. Milton for his paper on "Research and New Developments in Water Treatment". Other awards were as follows: Bessemer Premium to Mr. C. D. Mitchell, for his paper on "Prefabricated Pre-cast Concrete Structures"; Nursey Premium to Mr. R. Cecil Smart, for his paper on "Industrial Organisation as a Factor in Productive Efficiency"; Bernays Premium to Mr. Bernard Payne, for his paper on "Water Supply Engineering". Two other papers, namely, "The Engineer and the Law", by C. L. Boucher, and "Liquid Springs", by R. H. Bound, were of particular merit; but their authors, as members of Council of the Society, were ineligible for awards, and they were presented with certificates under seal. The new president of the Society is Mr. E. E. Turner, formerly chief engineer to H.M. Airship *R.*34, and an authority on high-speed engine lubrication.

Research on the Biochemistry of Brain Tissue

THE Rockefeller Foundation has given £9,000 for research at the Neuropsychiatric Research Centre at Whitchurch Hospital, Cardiff, for research on the normal and pathological biochemistry of brain tissue under the direction of Dr. Derek Richter. Whitchurch Hospital is one of the leading hospitals in Britain for the investigation and treatment of mental disorders, and a Neuropsychiatric Research Centre has recently been established for which the present grant has been made. The magnitude of the problem of nervous and mental disease in Britain alone is not generally recognized. There are more hospital beds occupied by mental patients than by all other diseases put together, and the annual cost of upkeep

exceeds £12,000,000. Research on mental disease has been very much neglected in the past. The object of the work now being carried out at Cardiff is to find out more about the working of the brain and nervous system in health and disease, so that this knowledge can be applied to the treatment of mental disorders of every kind. The lines of research now in progress include biochemical work on the enzymes in the brain, and work using the radioactive 'tracer' technique. Clinical research is also being carried out on problems related to schizophrenia, epilepsy and senility.

Capper, Pass Awards for Metallurgy

MESSRS. CAPPER, PASS AND SON, LTD., of Bristol, have offered the Institution of Mining and Metallurgy and the Institute of Metals £200 a year for seven years, to be applied as follows: (*a*) £100 a year for one or more awards for papers on some aspect of non-ferrous extraction metallurgy; (*b*) £100 a year for one or more awards for papers relating to some process or plant used in the extraction or fabrication of non-ferrous metals. Both awards are for persons engaged full-time in industry or practice. The Councils of the Institution of Mining and Metallurgy and of the Institute of Metals have appointed a joint adjudicating committee which will examine annually all papers published by both societies; no special applications should be made for these awards.

Scholarships at Foreign Universities, 1948–49

THE British Council has been informed that scholarships for the academic year 1948–49 will be offered to students and graduates of British universities and colleges by the Governments of a number of foreign countries, including Belgium, Hungary, the Netherlands, Sweden (with the Swedish Institute for Cultural Relations) and the University of Teheran, Persia. The scholarships are normally intended for study on the postgraduate level. They cover in general the cost of tuition and maintenance and in some cases the cost of travel. Two scholarships have also been offered by the University of Cologne, and two by the University of Munster. Negotiations with the Control Commission are proceeding with regard to facilities for food and accommodation. Particulars can be obtained from the Controller of the Education Division, the British Council, 3 Hanover Street, London, W.1.

University of London

THE following appointments in the University of London have been announced:

Dr. L. J. Audus has been appointed to the Hildred Carlile chair of botany tenable at Bedford College as from October 1, 1948.

Dr. Eric Boyland has been appointed to the University chair of biochemistry tenable at the Royal Cancer Hospital (Free) as from January 1, 1948. In 1935 he was appointed reader in biochemistry at the hospital.

The degree of Doctor of Science has been conferred on Sir Alfred C. G. Egerton, University professor of chemical technology in the Imperial College of Science and Technology.

Royal Institute of Chemistry: Annual Meeting

THE annual general meeting of the Royal Institute of Chemistry will be held during April 15–17 in Birmingham; this is the first occasion since the Institute was founded that the meeting has been held in the provinces, and in honour of the occasion the Birmingham and Midlands Section has arranged a programme of scientific and social events. The Lord Mayor of Birmingham will give a civic welcome to the president (Mr. Roche Lynche). The programme includes an exhibition, "The Chemist in the Midlands", to be held in the Central Technical College, Birmingham, which will feature the training of the chemist, research, production, and the chemist and the public services. The exhibition will be open to the public. Prof. R. P. Linstead will give a lecture on "The Chemical Research Laboratory, Teddington"; and Prof. Maurice Stacey will speak on "The New Fluorocarbon Chemistry". Visits have been arranged to the University of Birmingham and the Barber Institute of Fine Arts, Messrs. Chance Bros. glassworks at Smethwick, and Messrs. Marston, Thompson and Eversheds brewery at Burton-on-Trent.

Announcements

LORD BRABAZON OF TARA has been elected president of the Royal Institution in succession to the late Lord Rayleigh.

A MEMORIAL CEREMONY in honour of Max Planck is being arranged by the Max Planck Society for the Advancement of Science, the Academy of Science at Göttingen, the University of Göttingen, and the German Physical Society in the British Zone of Germany, and will be held in the University of Göttingen on April 23 at 11 a.m. This date would have been Planck's ninetieth birthday.

AN international symposium on the "Kinetics and Mechanism of Combustion and Ignition Reactions in the Gas Phase" will be held in Paris during April 26–May 1. This symposium is being organised by the Centre National de la Recherche Scientifique, with the assistance of the Rockefeller Foundation. Detailed information can be obtained from Prof. P. Laffitte, 12 rue Cuvier, Paris (5ème).

DR. RISTO JURVA has been appointed director of the Finnish Institute for the Exploration of the Sea.

DR. CYRIL J. W. HOOPER has been appointed editor and general secretary of the Society of Dyers and Colourists. Dr. Hooper, who was born in London in 1913, received his education at Tottenham County School and the Royal College of Science, and eventually obtained the London degree of Ph.D. for work in physical chemistry. After some experience in industry, he became reader with Messrs. Charles Griffin and Co., Ltd., and recently he has been librarian and information officer in the Research and Development Department of Ascot Gas Water Heaters, Ltd.

A JOINT meeting of the British Society for the History of Science with the Science Masters' Association, the Historical Association and the Association of Women Science Teachers will be held on March 9 at 5 p.m. in the Lecture Theatre of the Science Museum, South Kensington, London, S.W.7, to discuss "The Place of the History of Science in Education". The speakers will include Dr. E. J. Holmyard (chairman); Dr. Sherwood Taylor; Mr. G. Fowles, formerly chairman of the Science Masters' Association; Mr. S. M. Toyne, chairman of council, Historical Association; and Miss L. E. Higson, secretary of the Association of Women Science Teachers, and there will be a general discussion.

LETTERS TO THE EDITORS

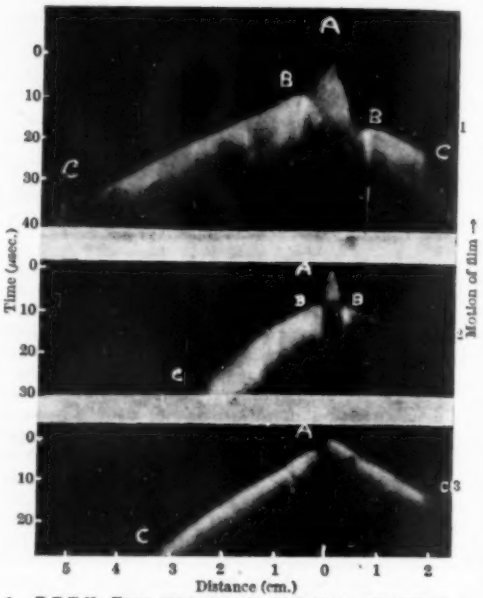
The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Birth and Growth of the Explosion in Solids Initiated by Impact

It has been shown that when liquid explosives such as nitroglycerine are initiated by impact, the explosion begins as a comparatively slow burning which spreads for a short distance from the point of initiation at a speed of *c.* 400 metres per second, and is then suddenly transformed into a faster propagation at *c.* 1,800 m./sec., which has the property of a detonation wave[1,2,3]. This two-stage propagation occurs when the initiation is caused by impact and compression of a small included bubble, or by sparking, and is observed with all the liquid explosives which have so far been investigated.

A recent study of the initiation of solid explosives by impact reveals a similar effect. If a thin film of the solid explosive is distributed on the anvil as an annulus, so that a small gas space is included during the impact, the sensitivity is increased[4]. Photographic experiments show that initiation begins at the gas space. This gives a convenient method of ensuring that the point of initiation is on the slit of the camera, and high-speed photographic studies of the growth of the explosion in the immediate vicinity of the point of initiation have been made both for secondary and for primary explosives. A typical result for a thin film of solid *P.E.T.N.* is given in Fig. 1. The initiation begins at *A* at the small included gas space, and the flame spreads from this point at a comparatively slow rate. In Fig. 1 this initial rate of burning (*AB*) is 450 and 300 m./sec. We should expect this rate to be dependent on film thickness, density of packing, etc., and in these experiments the rate varied from 100 to 600 m./sec. After a short distance (at the point *B*), this burning was transformed into a detonation, the speed of which varied from 1,000 to 2,500 m./sec. according to the density and film thickness of the explosive. In Fig. 1 this second stage (*BC*) is spreading at 1,620 m./sec. The transition from low-speed to high-speed propagation usually occurred at a physical discontinuity, that is, at the edge of the hammer, but this was not always the case. Films of cyclonite and tetryl gave similar results; but the initial burning was slower (100–300 m./sec.), and the thin film of explosive surrounding the hammer did not propagate.

A similar study has also been made of the initiation of primary explosives by gentle impact, both with and without added grit; when a grit particle was present, initiation began at the particle. The result for mercury fulminate initiated without grit is shown in Fig. 2. The two-stage propagation is again apparent. After initiation, the explosion spread for a short distance at a speed of 250–300 m./sec. before passing over to a high-speed detonation. Lead azide, on the other hand, usually showed no slow initial stage (see Fig. 3); detonation set in immediately unless extremely thin low-density films were used. It is interesting to note that for the *thermal* initiation of unconfined trains of these two primary explosives, Patry[5] found that fulminate gave an initial burning and azide did not.



1. *P.E.T.N.* From the point of initiation *A*, the explosion spreads as a slow burning *AB*, followed by a detonation *BC*. 2. Mercury fulminate. Similar to 1. 3. Lead azide. No initial burning

A parallel series of experiments was carried out with thin films of *P.E.T.N.*, mercury fulminate and lead azide confined between two surfaces and initiated at the centre by a spark instead of by impact. The growth of the explosion initiated by the spark was very similar to that obtained by impact. *P.E.T.N.* and mercury fulminate both gave an initial slow burning which changed over to a detonation (the photographs were similar to Figs. 1 and 2). With lead azide, the burning stage was not observed and the photograph was similar to Fig. 3.

It is clear that for a number of solid explosives the first stage of the initiation by impact is a burning, and that the general behaviour is very similar to that observed in liquids under similar conditions. It is probable that under the impact, many explosives, particularly the softer ones, are compressed and flow like liquids. The results again suggest that, for solids as well as for liquids, the initiation under impact is essentially thermal in origin, and that the explosion begins at a hot spot which can be generated either by the adiabatic compression of a gas pocket, or by friction on a particle of grit, or (under extreme conditions) by viscous heating of the rapidly flowing explosive.

We thank the Royal Society for a grant for the development of high-speed cameras and the Ministry of Supply (Air) for other equipment.

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Cambridge. Nov. 15.

[1] Bowden, F. P., Mulcahy, M. F. R., Vines, R. G., and Yoffe, A., *Proc. Roy. Soc.*, A, **188**, 311 (1947).
[2] Vines, R. G., and Mulcahy, M. F. R., *Nature*, **157**, 626 (1946).
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[4] Yoffe, A., *Nature* (see following communication).
[5] Patry, M., Thesis, Nancy (1933).

Initiation of Explosives by Adiabatic Compression of their own Vapour

PREVIOUS work has shown that the sensitivity of liquid explosives to impact is greatly increased by the presence of minute gas bubbles[1]. The initiation is of a thermal nature and is due to the adiabatic compression and heating of the trapped bubbles. A simple method of including a gas space in an explosive is to spread it as a small annulus on a flat anvil. When this is struck with a flat hammer, the small amount of gas in the centre is trapped and compressed.

In these experiments the size of the annulus was such that the initial volume of the gas space was *c.* 5×10^{-5} c.c. With nitroglycerine in air at atmospheric pressure, regular explosions are obtained with an impact energy of 300–500 gm. cm. When the nitroglycerine is spread as a continuous film so that gas spaces are not present, very high impact energies are necessary (10^5–10^6 gm. cm.). At low initial air pressures (less than 10^{-5} mm. mercury), it is found that the annulus still exercises a similar influence in increasing the sensitivity, and explosions are still obtained with impact energies of *c.* 500 gm. cm. Although the other gases have been pumped out, the vapour pressure of nitroglycerine itself at room temperature is *c.* 10^{-3} mm. The experiments suggest that the initiation of the explosion under these conditions is due to the compression and adiabatic heating of the nitroglycerine vapour itself. This would assume that the vapour is not condensed during the rapid compression produced by the impact. The same high sensitivity is obtained when the evacuated space is filled with 50 mm. of methyl nitrate vapour, another explosive similar to nitroglycerine. This supports the above view.

These results have a bearing on the handling of liquid explosives. The compression of any small space, whether filled with a gas or with the vapour of explosive only, may initiate an explosion. Such a condition could arise, for example, during the collapse of bubbles formed by cavitation.

When a solid such as *P.E.T.N.* is distributed on the anvil as an annulus rather than as a uniform film of crystals, an increase in the explosion efficiency is again observed: the energy necessary to give an explosion efficiency of 50 per cent is $2{\cdot}8 \times 10^4$ gm. cm. for an annulus and $7{\cdot}1 \times 10^4$ gm. cm. for a continuous film. This increase in efficiency due to the annulus occurs both when the air pressure is initially one atmosphere, and when it is initially less than 10^{-5} mm. and the total pressure, including that of the explosive vapour, is *c.* 10^{-4} mm. Again, it would appear that the compression of the vapour of the explosive may initiate the reaction.

The behaviour of some solid explosives under impact thus shows many similarities to that of the liquid explosives. Apparently the air spaces which are present between the crystals of solid explosive are sealed off by local melting or plastic flow during the impact, and the adiabatic compression of the air or vapour in these gas spaces may initiate the explosion.

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[1] Bowden, F. P., Mulcahy, M. F. R., Vines, R. G., and Yoffe, A., *Proc. Roy. Soc.*, A, **188**, 291 (1947).

Acetylation of Sugars

THE acetylation of sugars has hitherto involved the use of acetic anhydride and a catalyst such as sodium acetate[1], zinc chloride[2], sulphuric acid[3] or pyridine[4]. We have shown that glucose may be acetylated rapidly by means of a mixture of acetic anhydride and acetic acid if a small amount of perchloric acid is added to act as a catalyst[5]. No external application of heat is necessary to aid the reaction. By pouring the acetylation mixture into water, an almost quantitative yield of α-pentacetyl glucose is produced. This new procedure does not afford crystalline acetyl derivatives of galactose or mannose; but it works well for the acetylation of maltose, difructofuranose anhydride, α-methylglucoside, and polyhydric alcohols such as mannitol, sorbitol, erythritol, arabitol and pentaerythritol.

The method offers a rapid route to the formation of acetobromglucose and acetobrommaltose, inasmuch as the intermediate isolation of the acetylated sugars can be dispensed with and the acetylation reaction mixture treated directly with hydrogen bromide (cf. ref. 3). The advantages offered by this process arise not only from the fact that there is a great saving in time but also that the yields are improved. Thus acetobromglucose and acetobrommaltose, prepared as indicated above, give upon treatment in the usual manner with methyl alcohol in the presence of silver carbonate the corresponding tetracetyl β-methylglucopyranoside and heptacetyl β-methylmaltoside in yields of 55 per cent and 53 per cent respectively. Hitherto yields of 36 per cent and 24 per cent respectively have been recorded for the preparation of these glycosides by methods[6,7] involving the intermediate isolation of the acetates before treatment with hydrogen bromide.

A more detailed account of these experiments will be published elsewhere.

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[1] Tanret, *Bull. Soc. Chim.*, **13** (3), 261 (1895). Liebermann and Hörmann, *Ber.*, **11**, 1618 (1878). Herzfeld, *Ber.*, **13**, 265 (1880).
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Paper Chromatography of Flavine Nucleotides

PARTITION chromatography on paper[1] has not hitherto been reported for the analysis of riboflavine, its nucleotides and derivatives. However, 'Collidine', and a butyl alcohol–acetic acid mixture (shake 4 parts butyl alcohol with 1 part glacial acetic acid and 5 parts water, and use the upper layer), are two very suitable solvents for separating various flavine compounds, identified by their characteristic green fluorescence in ultra-violet light, which will detect as little as 0·01 μgm. flavine on the paper. The separated substances can be easily and quantitatively removed from the paper by the method of Dent[2] and used for enzymic or other experiments.

Approximate R_F values. $\left(R_F = \frac{\text{distance moved by substance}}{\text{distance moved by solvent}}\right)$

	'Collidine' ●	Butyl-acetic
Flavine adenine dinucleotide	0·11	0·02
Riboflavine phosphate	0·09	0·09
Riboflavine	0·5	0·3

About 0·005 ml. aqueous, protein-free and salt-free flavine solution is required for the analysis. The homogenized tissue, flavoprotein, etc., is denatured (by boiling for three minutes, or standing at *p*H 2 and room temperature for five minutes), half its weight of ammonium sulphate added, and the protein precipitate centrifuged off. The free flavine is then concentrated by extraction into liquid phenol, and returned to water by addition of ether to the phenol layer. Since liquid phenol readily extracts proteins (hæmoglobins, cytochrome *c*, diaphorase), it is important to use protein-free solutions. Xanthopterin and leucopterin are also concentrated by this procedure; but their fluorescence on the chromatogram is quite different, and they do not interfere.

Examination of various tissues of the rat and rabbit (heart, brain, kidney, liver) shows only the presence of flavine adenine dinucleotide and some riboflavine phosphate, but no free riboflavine or other flavine derivative. Even after five hours autolysis at 38° C. of homogenized rabbit liver at *p*H 6·8, the flavine it contains is all protein-bound, and no riboflavin is produced. This suggests that there is no true storage of riboflavine as such in rabbit liver. Rabbit spleen homogenate, on the other hand, contains no flavine adenine dinucleotide or riboflavine phosphate, and added flavine adenine dinucleotide is rapidly broken down to riboflavine by an enzyme also present in acetone powder of spleen. This enzyme was also found independently by Comline and Whatley[3] at the same time.

In view of its sensitivity, this method seems very suitable for the analysis of enzyme prosthetic groups.

I would like to thank Dr. M. Dixon for suggesting and encouraging this work, which was supported by a grant from the Medical Research Council.

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Nov. 22.

[1] Consden, R., Gordon, A. H., and Martin, A. J. P., *Biochem. J.*, **38**, 224 (1944).
[2] Dent, C. E., *Biochem. J.*, **41**, 245 (1947).
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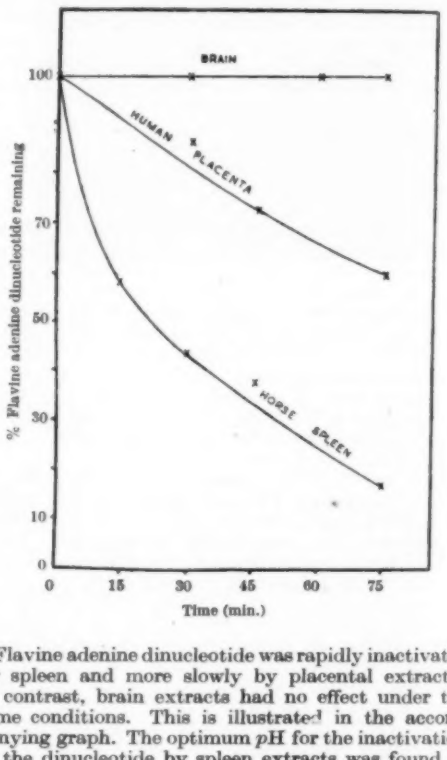
Inactivation of Flavine Adenine Dinucleotide by Tissue Extracts

RECENT experiments[1] on the synthesis of acetylcholine by tissue extracts, especially from acetone-dried brain, human placenta, and horse spleen; have shown that flavine adenine dinucleotide probably plays an essential part. It was found that spleen extracts only formed small amounts of acetylcholine under conditions giving a large synthesis with brain and placental extracts. Saline extracts of acetone-dried spleen, however, were found to contain a powerful inhibitor of acetylcholine synthesis. The effect of the inhibitor, which has the properties of an enzyme, was counteracted by adding large amounts of flavine adenine dinucleotide. This suggests that the inhibitor is an enzyme which breaks down flavine adenine dinucleotide; the action of tissue extracts on the dinucleotide has therefore been investigated in more detail.

Samples of flavine adenine dinucleotide were incubated at 37° C. for varying periods with saline extracts of acetone-dried guinea pig brain, human placenta or horse spleen. The samples were then placed in a boiling water-bath for 45 sec., cooled, and the coagulated protein centrifuged down. The flavine adenine dinucleotide content of the supernatant was estimated with a preparation of *d*-amino-acid oxidase protein from which the prosthetic group (flavine adenine dinucleotide) had been removed[2].



Flavine adenine dinucleotide was rapidly inactivated by spleen and more slowly by placental extracts; in contrast, brain extracts had no effect under the same conditions. This is illustrated in the accompanying graph. The optimum *p*H for the inactivation of the dinucleotide by spleen extracts was found to be about *p*H 7·2. After incubation for 75 min. with spleen extracts, the dinucleotide solutions had no effect on the synthesis of acetylcholine by human placenta.

These results may help to explain why brain extracts, in contrast to placental extracts, do not require a further addition of flavine adenine dinucleotide for maximal synthesis of acetylcholine. Spleen extracts, which rapidly inactivate the dinucleotide, only synthesize acetylcholine to an appreciable extent on the addition of very large amounts of the flavine adenine dinucleotide.

The presence in spleen of an enzyme breaking down flavine adenine dinucleotide was also shown at the same time by Crammer[3], using chromatographic methods.

Extracts of horse spleen did not reduce the oxygen uptake of unsplit *d*-amino oxidase, even after incubation for 1 hr. at 37° C. prior to adding the alanine; in addition, the splenic extracts did not prevent the

reactivation of split *d*-amino-acid oxidase protein when added, together with flavine adenine dinucleotide, immediately before measurement of oxygen uptake, provided the spleen and the dinucleotide had not been previously incubated. This indicates that in the amino-acid oxidase system, the dinucleotide is not present to any considerable extent in the free state, but is bound to the oxidase protein.

From results on acetylcholine synthesis, it appears that the activator[4], which is another coenzyme required for this synthesis and which is probably identical with the coenzyme of acetylation[5], is also destroyed by spleen extracts.

These results will be fully described elsewhere. One of us (R. S. C.) has a research grant, and the other F. R. W.) has a research training grant, from the Agricultural Research Council.

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[1] Comline, R. S., *J. Physiol.*, **105**, 6*P*, 7*P* (1946).
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New Amino-Acids in Bacterial Hydrolysates

As part of the programme in this Laboratory of studying the relation between a bacteriophage and its host organism, analyses have been made of the amino-acid contents of hydrochloric acid and barium hydroxide digests of *E. coli*. The methods used for this have been the partition chromatography of Consdon, Gordon and Martin[1] as modified[2] to yield quantitative results. The following known amino-acids have been identified in these hydrolysates: aspartic and glutamic acids, serine, glycine, alanine, threonine, valine, isoleucine, leucine, methionine, tryptophane, phenylalanine, tyrosine, proline, arginine, lysine and histidine. In addition, three weak spots, indicated by the letters *a*, *b*, *c* in Fig. 1, have been noticed which do not correspond to known naturally occurring amino-acids. Spots *b* and *c* have only been visible when concentrated hydrolysates containing *c*. 40 mgm. N/c.c. have been applied to the paper.

M Cresol + 0·1% ammonia

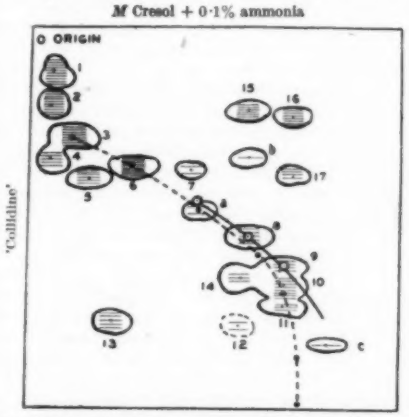

Fig. 1. Two-dimensional chromatogram of a 24-hour hydrochloric acid digest of *E. coli* organisms in *M* cresol + 0·1% ammonia and 'Collidine'

Aspartic acid, 1, glutamic acid, 2, glycine, 3, serine, 4, threonine, 5, alanine, 6, histidine, 7, valine, 8, *iso*leucine, 9, leucine, 10, phenylalanine, 11, tryptophane (present in barium hydroxide digests), 12, tyrosine, 13, methionine, 14, lysine, 15, arginine, 16, and proline, 17. The new amino-acids are *a*, *b* and *c*. The solid circles are the straight-chain amino-acids, and the open circles are the branched-chain compounds

M Cresol + 0·1% ammonia

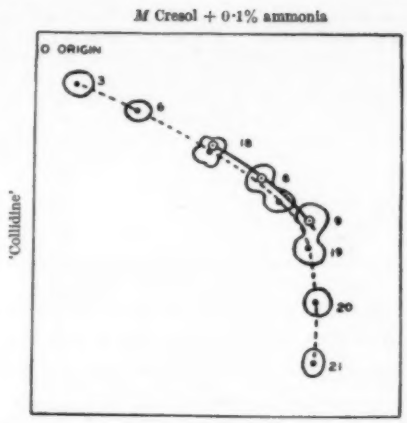

Fig. 2. Two-dimensional chromatogram of a mixture of aliphatic amino-acids

Glycine, 3, alanine, 6, α-amino *iso*butyric acid, 18, valine, 8, *iso*leucine, 9, *nor*leucine, 19, α-amino *n*-heptylic acid, 20, and α-amino *n*-caprylic acid, 21. The solid circle just below 18 is the position of α-amino *n*-butyric acid and the solid circle just below 8 is that of *nor*valine

Since Consdon, Gordon and Martin have shown that chemically related amino-acids occupy certain definite regions on a two-dimensional paper chromatogram, conclusions can be drawn regarding their probable identity. With the pair of solvents *M* cresol + 0·1 per cent ammonia plus a trace of cupron and 'Collidine' used in this work, the acidic, glutamic and aspartic acids occupy a region close to the origin. The basic arginine, lysine and histidine are in the top middle, while the neutral aromatic amino-acids tyrosine, phenylalanine and tryptophane are along the bottom of the chromatogram. Proline is an exception which, because of its high solubility in both organic and watery phase, forms a spot in the region of the bases. The neutral aliphatic amino-acids are regularly distributed. Whatever the pair of solvents employed, the straight-chain homologues of glycine and alanine always fall on a smooth curve. Branched-chain components of this series behave similarly, but their curves are slightly displaced. This is illustrated by Fig. 2, which is a tracing from a two-dimensional chromatogram of an artificial mixture containing the following substances: glycine, alanine, α-amino butyric acid, α-amino *iso*butyric acid, valine, *nor*valine, *iso*leucine, *nor*leucine, α-amino *n*-heptylic acid and α-amino *n*-caprylic acid.

Positions of the unidentified spots relative to the curves of the aliphatic amino-acids suggest that spot *c* may be due to a branched-chain isomer of α-amino *n*-heptylic acid. Spot *a* coincides exactly with that produced by α-amino *n*-butyric acid on a chromatogram of a standard mixture of amino-acids. Spot *b* lies in the region of the bases, but so far has not been identified.

There has been much controversial evidence about the occurrence of α-amino *n*-butyric acid in hydrolysates of proteins. It was reported to occur in alkaline hydrolysates of silk fibroin by Schützenberger

and Bourgeois[3], but this was shown to be incorrect by Fischer and Skita[4]. Foreman[5] isolated a compound from casein which he believed to be this amino-acid; but its melting point was lower than that reported for the synthetic product of Fischer and Mouneyrat[6]. Recently, Dent[7] has found it in the urine, blood and dilute acetic acid extracts of yeast.

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[1] Consdon, R., Gordon, A. H., and Martin, A. J. P., *Biochem. J.*, **38**, 224 (1944).
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[7] Dent, C. E., *Science*, **105**, 335 (1947).

Citric Acid in Semen

The discovery of citric acid in mammalian semen is due to Scherstén[1,2], who was also the first to point out that the acid originates in the accessory glands of reproduction, chiefly the seminal vesicles. In this respect citric acid resembles another more recently discovered component of semen, namely, fructose[3], which has similarly been shown to be secreted mainly in the seminal vesicles[4,5]. The present study was undertaken primarily with the view of investigating the possibility that there may exist a link between the two substances with regard to their formation, distribution or function in reproductive organs and semen. Citric acid was estimated colorimetrically[6,7]. The results were briefly as follows.

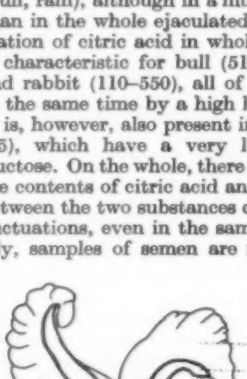
(1) Citric acid constitutes a major component of the seminal plasma. With the exception of the rabbit, it is usually absent from epididymal semen. It can be present, however, already in the ampullar semen (bull, ram), although in a much smaller concentration than in the whole ejaculated semen. A high concentration of citric acid in whole semen (mgm./100 ml.) is characteristic for bull (510–1,100), ram (110–260) and rabbit (110–550), all of which are distinguished at the same time by a high level of seminal fructose. It is, however, also present in boar (130) and stallion (55), which have a very low content of seminal fructose. On the whole, there is no correlation between the contents of citric acid and fructose, and the ratio between the two substances can undergo considerable fluctuations, even in the same individual. Occasionally, samples of semen are met with which contain only one but not the other component; for example, on two occasions we had the opportunity of examining samples of fish semen (*Scylliorhinus caniculus*) which contained fructose but not citric acid. On the other hand, dog semen seems to be devoid of both fructose and citric acid.

(2) The accessory organs of reproduction are the chief contributors of both seminal fructose and citric acid, yet the two substances can be shown to originate in different parts of the genital system. In rabbit, for example, citric acid is met with principally in the glans vesicularis and is associated frequently with the gel formation, whereas fructose is found in the highest concentration in the prostate organ[8]. An even clearer picture was obtained through the study of the reproductive organs in the rat. The distribution of citric acid and fructose in the various parts of the reproductive system of the male rat is shown in the accompanying sketch, where it can be seen that citric acid occurs chiefly in the ventral prostate and in the seminal vesicle, whereas fructose is found mainly in the dorsal prostate and in the 'coagulating gland', that is, the structure adjacent to the seminal vesicle proper.

(3) Following castration, there is a remarkable fall in the citric acid content of semen. In this respect, citric acid resembles fructose[9]. However, the post-castrate disappearance of citric acid is not so rapid as that of fructose. In rabbit, for example, the decrease may not become noticeable until three weeks after castration, whereas fructose has usually disappeared almost completely by the end of the second week. Similarly, the reappearance of citric acid in response to testosterone usually follows some time after seminal fructose.

(4) When fresh semen is incubated *in vitro*, citric acid disappears. The rate of disappearance, however, is much lower than that of fructose. In bull and ram semen, for example, the rate of fructolysis[10] at 37° C. is 1·5–2 mgm. fructose/10^9 sperm cells/1 hour, as compared with some 0·05 mgm. citric acid. Moreover, the rate at which spermatozoa metabolize fructose is not affected by the presence of citrate. On the other hand, the process of 'citricolysis', although very slow, may continue in semen for some time after the spermatozoa have exhausted the entire reserve of seminal fructose, that is, after the 'fructolysis' has come to an end.

(5) The observation has been confirmed that mammalian spermatozoa contain aconitase and that they are able to synthesize citric acid from oxaloacetic acid[11]. However, the bulk of the citric acid present in whole ejaculated semen is derived from the seminal plasma and not from the spermatozoa. It can be removed by centrifuging the semen and by washing the spermatozoa with Ringer solution. Citrate added to washed ram spermatozoa is incapable of maintaining the sperm respiration. In this respect it differs from fructose as well as from many organic acids such as lactic, pyruvic, oxaloacetic, acetic, propionic and butyric, all of which can maintain and prolong the respiration of washed spermatozoa.



	Weight of organ (mgm.)	Citric acid (mgm./100 gm. tissue)	Fructose (mgm./100 gm. tissue)
Seminal vesicles	780	39	9
Coagulating glands	130	0	172
Median prostate	20	60	90
Ampullæ vas. def.	70	0	10
Dorsal prostate	250	20	82
Ventral prostate	320	122	0

This work has been carried out on behalf of the Agricultural Research Council. We wish to acknowledge help and advice from Prof. D. Keilin, Mr. J. Burkhardt,

Dr. D. V. Davies, Mr. J. A. F. Fozzard, Miss U. Parsons, Mr. R. W. Pomeroy and Dr. A. Walton.

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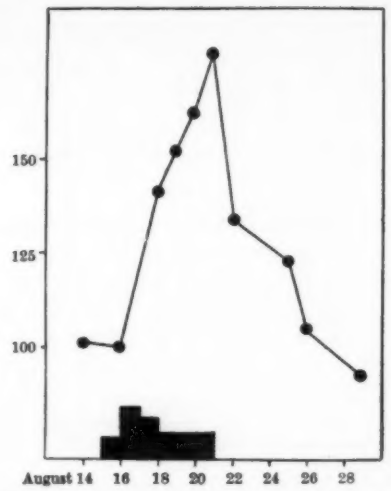
Effect of *p*-Aminobenzoic Acid on the Leucocyte Count in Leukæmia

A LEUCOPENIC effect of *p*-aminobenzoic acid has been noticed in several studies on the treatment of rickettsial infections in man with this drug[1].

In the Radiumstationen in Aarhus we have investigated this effect of *p*-aminobenzoic acid on the leucocyte count in leukæmia. The drug was given to a few patients with chronic leukæmic leukæmia (four patients with chronic lymphatic leukæmia and two patients with chronic myeloid leukæmia). The administration and dosage were at first as recommended in rickettsial infections (about 2 gm. every second hour); later the dosage was considerably decreased without any influence on the effect. In all six cases the administration of *p*-aminobenzoic acid caused an abrupt rise in the leucocyte count, which continued to increase so long as the drug was given. The daily increase was 10,000 to 100,000 or more cells per c.mm., demonstrated both in capillary blood from the ear lobule and in the venous blood from the cubital vein. When the leucocyte count had been increasing for four or five days, the patients often complained of pressure and soreness in the swollen lymph glands and in the enlarged spleen, and consequently the administration of *p*-aminobenzoic acid was stopped. Hitherto X-ray therapy has been instituted immediately after the withdrawal of *p*-aminobenzoic acid, and the decrease in leucocytes has followed as usual or perhaps a little more rapidly. The increase in the leucocyte count caused by *p*-aminobenzoic acid was accompanied in the myeloid leukæmias by a slight shift to the left, which could be demonstrated more clearly in the bone marrow. Corresponding changes could not be demonstrated in the lymphatic types. Hæmoglobin and erythrocyte count were unaffected.

The mechanism of the effect of *p*-aminobenzoic acid in leukæmia is not yet clear. Experiments concerning this point are in progress in this Laboratory. Experiments have shown that an acidosis produced by ammonium chloride does not affect the leucocyte counts in leukæmic patients, so we may exclude the possibility that the slight acidosis which often results from treatment with *p*-aminobenzoic acid is the cause of the rise in leucocyte counts.

p-Aminobenzoic acid has been given to eight patients with non-leukæmic diseases (normal blood picture) without causing any significant variations in the leucocyte counts. Consequently there seems to be a difference in the effect of *p*-aminobenzoic acid on the normal and leukæmic leucocytes.



EFFECT OF *p*-AMINOBENZOIC ACID IN A CASE OF CHRONIC MYELOID LEUKÆMIA. THE LEUCOCYTE COUNT (THOUSANDS PER C.MM.) PLOTTED AGAINST TIME. THE BLACK AREA INDICATES THE DISTRIBUTION OF *p*-AMINOBENZOIC ACID, WHICH WAS GIVEN FROM AUGUST 15 UNTIL AUGUST 20 INCLUSIVE, 1946, THE TOTAL DOSE BEING 52 GM. X-RAY THERAPY WAS INSTITUTED ON AUGUST 21

This investigation was carried out with financial support from the Lady Tata Memorial Foundation and Anders Hasselbalchs Anti-Leukemia Foundation.

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Electron Microscope Observation of Renosine

RENOSINE is the structure-protein of the kidney discovered by I. Banga and A. Szent-Györgyi[1]. It constitutes up to a third of the total protein content of the kidney, is highly viscous, exhibits thyxotropy and an intense negative double refraction of flow. It contains inextractable phosphorus and seems thus to be a nucleoprotein.

To determine visible renosine micelles, the following electron microscopical investigations were carried out. Renosine extracts were prepared, according to a method similar to that described by Banga and Szent-Györgyi, from guinea pig kidneys by means of Edsall's solution containing 30 per cent urea. For further purification, the renosine was precipitated and dissolved once more. The solutions tested were centrifuged (10,000 revolutions) for one hour, and 1 ml. of the top layer was diluted with the solution used in the extraction in the ratio of 1 : 100 or more. A droplet of the diluted solution was placed upon the aluminium film of the specimen grid. After drying, it was rinsed for a short time with twice-distilled water and dried again.

The electron micrographs of such renosine preparations show filaments that tend to branch and split

longitudinally. The average width of these filaments, which could be seen to be complete and individual, measured 73 ± 19 A.

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Raman Spectra of Some Synthetic Mixtures of α-Chloroacids

DUCHESNE has criticized[1], from a theoretical point of view, the use in our work[2] of the fact that the Raman spectrum of a mixture of α-chloroacids consists of a superposition of the spectra of the constituents. He believes that the Raman spectra of the pure α-chloroacids which we reproduced include some characteristic features which he considers indicate association; in these conditions, Duchesne writes, the additivity of the spectra for a mixture is an unjustifiable assumption.

Proceeding, however, with our investigations, we have had occasion to study the Raman spectra of synthetic mixtures of α-chloroacids and particularly (1) a mixture containing 30 per cent α-chloro*iso*caproic acid and 70 per cent α-chloro*iso*valeric acid, and (2) a mixture containing 40 per cent α-chlor-β-methylvaleric acid and 60 per cent α-chloro*iso*caproic acid. Using a comparator, we have measured, on the spectra of the pure products and of their mixtures, the frequencies which are most suitable for characterizing each of these acids in these mixtures. The accompanying tables sum up the results given by four series of determinations.

TABLE 1

Pure α-chloro*iso*-valeric acid ν (cm.$^{-1}$)	Synthetic mixture (1) ν (cm.$^{-1}$)	Pure α-chlor-β-methylvaleric acid ν (cm.$^{-1}$)	Synthetic mixture (2) ν (cm.$^{-1}$)
341 ± 2	341	775 ± 2	773
369 ± 3	369	803 ± 3	804
789 ± 2	791	983 ± 2	983
841 ± 2	843	1036 ± 2	1034
902 ± 2	904		
1236 ± 2	1235		

TABLE 2

Pure α-chloro*iso*caproic acid ν (cm.$^{-1}$)	Synthetic mixture (1) ν (cm.$^{-1}$)	Synthetic mixture (2) ν (cm.$^{-1}$)
289 ± 3	289	290
315 ± 3	313	313
830 ± 2	830	829
891 ± 2	889	890
929 ± 2	930	929
1208 ± 2	1207	1210
1342 ± 2	1344	1340

Examination of these tables clearly shows that, within experimental errors, the spectrum of a mixture of α-chloroacids consists, in the range of wavelengths we have chosen for our qualitative determinations, of the superposition of the constituent spectra. This conclusion is, of course, in no way original. Several investigators have shown that the Raman spectrum of a mixture of chemically similar substances is the exact superposition of the constituent spectra. Dadieu and Kohlrausch[3] write, indeed: "Auch in Fällen, wo man infolge der Abweichung vom Raoultschen Gesetz starke Assoziation bzw. Molekülbld. annehmen muss ist das Ramanspektrum des Gemisches innerhalb der Fehlergrenzen eine exakte Superposition der Einzelspektren"; and Goubeau[4] adds: "In der Mehrzahl der Fälle findet in Gemischen praktisch eine reine Uberlagerung der Spektren der Einzelsubstanzen statt. Dies gilt streng nur für Gemische von dipollosen Stoffen weiterhin noch für Gemische, deren Bestandteile ungefähr ein gleich grosses Dipolmoment bezitzen."

Duchesne also criticizes the precision of the measurements, which, he says, is illusory. It seems to us contradictory that the precision of our measurements should be illusory while it allows Duchesne to come to conclusions suggesting doubts about the value of our results. Finally, Duchesne criticizes the fact that intensity ratios of the spectral lines do not remain constant in the different mixtures. This has no more justification than the other criticisms. In fact, we agree with Stamm[5], who writes of the Raman spectra of mixtures: "It is true that slight intensity alterations may occur, but they will be so small as to be of importance only for quantitative analysis". Finally, it may be added that when the intensity of the lines has been estimated with the eye, and when the background of the spectrum is rather intense (this occurs for the spectra of some of our mixtures), one does not require for such a determination the precision of measurement given by a photo-electric cell.

A paper on this subject is being submitted to the *Bulletin des Sociétés Chimiques de Belgique*.

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Regeneration of Prothrombin Activity by Carbon Dioxide

IN an earlier communication[1], it was reported that the loss in prothrombin activity of plasma on storage may be due to the formation of substances in plasma which inhibit the activity. It was also shown that the loss in activity can be restored by passing carbon dioxide through the plasma.

The mechanism of regeneration of the activity of prothrombin by carbon dioxide has been investigated, and we have been able to prove conclusively that carbon dioxide does not exert any direct influence on the enzyme but regenerates the activity by neutralizing the effect of the inhibitors formed during the period of storage of plasma.

Plasma, in which the prothrombin is reversibly inactivated as a result of storage, was subjected to ultra-filtration; whereby the enzyme was separated from the ultra-filtrate which contains the inhibitors. The residue after ultra-filtration was dissolved in physiological saline, and its activity was tested both before and after passing carbon dioxide. It was found that there was no difference in activity between the two, which clearly shows that carbon dioxide does not act on the enzyme.

The ultra-filtrate containing the inhibitors was divided into two portions, and carbon dioxide was passed through one of them. Equal amounts of the above two samples of the ultra-filtrate were added to two equal portions of the same enzyme solution, and it was found that the enzyme solution to which ultra-filtrate treated with carbon dioxide was added had a higher activity than the one treated with ultra-filtrate alone.

This clearly shows that carbon dioxide in some way neutralizes the action of inhibitors which are formed during the period of storage, thereby increasing the prothrombin activity of reversibly inactivated plasma.

In the accompanying table are presented the results of a typical experiment, using the same sample of plasma.

Treatment	Prothrombin activity (coagulation time)
Bovine plasma (fresh)	15 sec.
Bovine plasma (reversibly inactivated on storage)	
Before passing carbon dioxide	30 ,,
Bovine plasma (reversibly inactivated on storage)	
After passing carbon dioxide	15 ,,
Reversibly inactivated plasma (before ultra-filtration)	30 sec.
Ultra-filtered plasma	18 ,,
,, ,, + CO_2	17 ,,
,, ,, + ultra-filtrate	40 ,,
,, ,, ,, + CO_2	24 ,,

Our thanks are due to Prof. V. Subrahmanyan for his interest in this investigation.

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Ovarian Activity in the Pregnant Mare

Ovarian activity in the mare in early pregnancy presents some unusual features which are inconsistent with the accepted normal behaviour of the mammalian gonad during gestation. In the first place, the corpus luteum of pregnancy is very short-lived, and unlike that of most other mammals its period of activity would not seem to be prolonged much in excess of that of the œstrous cycle of the non-pregnant animal. Harrison[1] has observed that the corpus luteum of pregnancy completely fills the cavity of the ruptured follicle in four to six days and attains maximum size by the tenth to fourteenth day. Regression is stated[2] to occur at about the end of the first month. Secondly, follicular development is a common feature of ovarian activity at this time, and Day[3] has observed the occurrence of ovulation in a mare on the twenty-third day of pregnancy. Ovarian activity reaches its peak during the second and third month of pregnancy, when gonadotrophic hormone is abundant in the blood.

Ovulation of the many Graafian follicles which are brought to maturity by these hormonal means was recently doubted[4], but a more extensive search has now shown that it occurs in a high proportion of pregnant mares. To date we have recovered one or more ova from the Fallopian tubes of nine of fourteen mares which have been examined post-mortem when 46–73 days in foal. The ovaries of all these fourteen mares contained one or more fully formed corpora lutea; but in none, with the possible exception of one mare examined on the 46th day, could the primary corpus luteum of pregnancy be recognized. It is highly probable that during this stage of pregnancy a succession of follicles ovulate, from which corpora lutea are rapidly formed to maintain gestational requirements. Of the nine mares from which ova were recovered, ovulation had occurred in five from the right, in two from the left, and in the remaining two from both left and right ovaries. In all, fifteen ova were recovered, nine from the right and six from the left Fallopian tubes; three of the latter were found in one tube. The corpora lutea of the whole series were distributed in a proportion of 22 to 18 between the left and right ovaries. There is no reason, therefore, to suppose that the frequency of ovulation between the two ovaries is dissimilar.

Our observations on ovulation during the œstrous cycle, however, show that it occurred more frequently in the left ovary, and our findings are in close agreement with the extensive data of Kedrov[5]. We have palpated per rectum 24 mares during 45 cycles and have observed that of 36 single ovulations 22 occurred in the left and 14 in the right ovaries, and that of 9 twin ovulations 4 took place in the left ovary and the remaining 5 involved both ovaries. This greater activity of the left ovary is of interest especially in view of Kedrov's findings that implantation occurs more frequently in the right horn of the uterus. Last summer we examined, either post-mortem or by rectal palpation, the uteri of fifteen mares carrying single pregnancies, of which thirteen were implanted in the right horn. Only in four of these thirteen mares could we be certain that ovulation at the time of mating occurred in the right ovary alone. In another eight it was established that ovulation took place only in the left ovary. We have encountered twin pregnancy in five mares; in two of them the ovulation of two follicles was recognized, at the time of mating, as having occurred in the left ovary. Fœtal migration occurred in both mares; in one, a fœtus had become implanted in each horn, and in the other the right horn contained both conceptuses. In this small series of twenty pregnancies, fœtal migration had occurred in ten mares, the direction of the migration being in all instances from left to right. A high incidence of fœtal migration was reported by Day, but, unlike us, he observed its occurrence in both directions within the uterus.

We have undertaken preliminary investigations on the fertilizability of the ova which are discharged from the ovaries in early pregnancy with the ultimate object of inducing a second concurrent pregnancy and observing the course of secretion of gonadotrophin into the blood. Two pregnant mares in which mature follicles were palpable were injected intravenously with 1,500 I.U. of chorionic gonadotrophin and inseminated artificially with 20 ml. of stallion semen. They were examined four days later after they had been bled to death under anæsthesia. One was found to have aborted a twin pregnancy and no ovum was recovered from the Fallopian tubes. The other, which at the time of injection and insemination was about to ovulate from the left ovary and was pregnant in the right uterus, had not aborted; ovulation had occurred but the ovum recovered from the left tube had not been fertilized. Failure to effect fertilization in the latter mare is

ascribed to the existence of a mechanical barrier to sperm migration presented by a non-patent cervix or by an encroachment of the fœtal sac into the non-gravid left uterine horn. It is hoped to exclude the latter possibility by repeating this experiment at an earlier stage in pregnancy.

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Bile Acids of the Whale

As part of a general investigation into the nature of the 'bile salts' of vertebrates, we have examined the bile of a whale. So far as we know, no work on the 'bile salts' of cetaceans has previously been done. Through the kindness of Dr. M. Begg, of "Discovery" Investigations, we obtained bile from the fin whale (*Balænoptera physalus*): 3,000 ml. bile were collected from either the duodenum or the 'third stomach' of a single whale, and preserved with alcohol. The main biliary constituent has been found to be cholic acid, conjugated, apparently, chiefly with taurine. The chief 'bile salt' in this animal therefore resembles that of the teleostean fish, snakes and the majority of mammals so far investigated.

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Production of Helium by Cosmic Rays

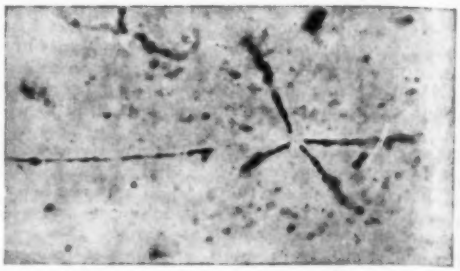
In a recent experiment, a packet of Ilford's nuclear research plates (type *C*2) was exposed to cosmic rays for a period of six weeks at the summit of Mont aux Sources (11,000 ft.), Basutoland.

A preliminary examination of these plates has revealed several features of interest; the present communication, however, is concerned with one only of these, namely, the large number of nuclear disintegrations which occurred in the glass bases of the plates. These disintegrations become evident, of course, only when the product particles cross the glass surface and enter the emulsion. They then give rise either to a single track or to a 'star', which differs from a star originating in the emulsion in that its rays do not actually meet. The accompanying photomicrograph illustrates this.

The following classification summarizes observations over 4 sq. cm. of one of the plates. No disintegration is included which originates at a greater depth in the glass than 20 microns.

	2 rays	3 rays	4 rays	5 rays	Total
Number of stars	44	55	18	5	122

This is equivalent to a minimum of 15,000 disintegrations per c.c. of the glass. The great majority of the tracks appear to be due to α-particles, but if the conservative estimate of one α-particle per disintegration is allowed, the conclusion is that helium is produced in the glass at the rate of at least 10^9 atoms per c.c. per annum.



Disintegration of a nucleus within the glass base of the photographic plate. Cooke × 95 immersion objective focused on the glass/emulsion surface

The chemical composition of the glass (by courtesy of Messrs. Ilford, Ltd.), excluding substances present in amounts of less than 1 per cent, is: SiO_2, 72; Na_2O, 14; CaO, 9; MgO, 3 per cent. Now these five elements, constituting 98 per cent of the glass, are among the most abundant and most widespread in the lithosphere. Oxygen, the most plentiful, accounts for 47 per cent of the earth's crust; silicon is next in order, with 28 per cent; calcium and sodium, fifth and sixth, with 4 and 3 per cent; magnesium, 2 per cent.

Rayleigh found that helium is present in almost all minerals. Its ubiquity has usually been ascribed solely to the presence of radioactive minerals throughout the earth's crust. The experimental results referred to above appear to indicate, however, that cosmic radiation may be responsible, first, for some part of the helium occluded in rocks, and secondly, for its widespread occurrence.

Estimates of the age of rocks and of meteorites obtained from measurements of the volume of helium occluded in them are based on the assumption that the helium is derived from radioactive minerals. If, however, cosmic radiation is also responsible for the production of measurable quantities of helium, then these estimates would appear to be unreliable in cases where the amount of helium is small. An example may illustrate this. The age of the Bethany meteorite[1] has been calculated as 100 million years on the basis of an analysis showing a helium content[2] (of radioactive origin) of 4×10^{-5} c.c. per 100 gm. But a short calculation shows that the helium produced by cosmic rays in the soda glass used in the Mont aux Sources experiment would amount to at least 2×10^{-5} c.c. per 100 gm. in the same geological period.

The estimate of the age of rocks by the helium method has always been reckoned to yield a minimum figure since helium diffuses so readily. If, however, a part of the occluded helium has been produced by cosmic rays, this 'minimum' will, in certain cases, need to be reduced.

My thanks are due to Prof. G. T. R. Evans, head of the Physics Department, for his personal interest in this research.

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Phase-Contrast in Polarized Light

In a recent communication, Hartley[1] indicated a simple arrangement for realizing phase-contrast in polarized light. It consisted of a quarter-wave plate cut in two and reassembled after 90° rotation, so that the dioptric rays and the diffracted rays, crossing respectively the two parts of the plate, are changed in phase with respect to each other. This same method was indicated by one of us[2] at the international conference of the Institut d'Optique, Paris, held in October 1946, and its efficiency has been tested since by experiment. We tested also another design which has the advantage of giving the exact phase-change needed and independently permits the weakening of the dioptric rays in a continuous manner so that it can be adjusted to optimum intensity. (In the last paragraph of his letter in *Nature*, Hartley indicated a modification of his design in order to obtain also the weakening of the dioptric rays; in doing so, however, the correct phase retardation given by his first arrangement is lost.)

Our system is based on the following principle. The incident light is polarized by a 'Polaroid' screen before crossing the object. In the conjugate plane of the light source (which was a rectilinear slit in our experiment but which could have any other form, like a ring) there is a half-wave plate followed by a quarter-wave plate. The half-wave plate is cut into three, and the part to be crossed by the dioptric rays is rotated 45° to the rest of the surface (Fig. 1). In this manner the diffracted rays, and the dioptric rays after crossing this composite plate, have their vibrations oriented at right angles to each other, without any modification in phase. In crossing the quarter-wave plate placed behind, the convenient phase change between them is then obtained. The analyser (another 'Polaroid' screen) isolates the vibration components parallel to its principal direction[3].

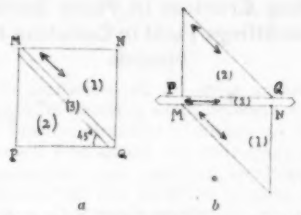

Fig. 1. (*a*) PLATE IS CUT INTO THREE PORTIONS, 1, 2, 3. (*b*) PORTION 3 IS TURNED THROUGH 45° AND INSERTED BETWEEN 1 AND 2

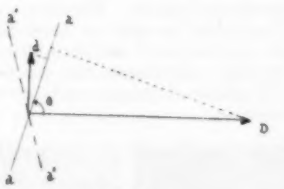

Fig. 2

Let D be the amplitude of the vibration in the dioptric rays, d that in the diffracted rays (Fig. 2) and θ the angle between the principal direction of polarizer (also the direction of vector D) and analyser. If $\theta = 90°$, the dioptric rays are suppressed and the system is equivalent to dark-ground illumination. If θ is less than 90° (position $a-a$ of the analyser) the resultant vibration will be: $D \cos\theta + d \sin\theta$, and the diffracted amplitude will add its effects to the dioptric amplitude. The system gives positive phase-contrast. If θ is greater than 90° (position $a'-a'$ of the analyser) the resultant vibration will be $D \cos\theta - d \sin\theta$ and the diffracted amplitude will be subtracted from the dioptric amplitude. We have negative phase-contrast. By rotating the analyser we can obtain zero intensity for $\cot\theta = d/D = \tan\varphi$.

If the diffracted light is produced by a small elevation of the object surface, the optical height z of this elevation will be given by the formula

$$z/\lambda = \frac{\varphi}{2\pi},$$

provided that $\varphi = \pi/2 - \theta$ remains a small angle.

In Fig. 3 are reproduced photographs taken for the three cases mentioned; the object is a piece of plain glass on which appears a line of transparent varnish (1—1) and, crossing it, a small furrow made by a diamond point (2—2). The composite half-wave plate used was cut in a fine 'Cellophane' sheet and imbedded in Canada balsam between optically flat glass plates. The quarter-wave plate was an ordinary $\lambda/4$ mica plate. The photographs were taken in monochromatic light (mercury 5461Å.).

Fig. 3. (*a*) NEGATIVE PHASE-CONTRAST. (*b*) DARK-GROUND ILLUMINATION. (*c*) POSITIVE PHASE-CONTRAST

An ingenious method of combining variable phase-contrast with variable amplitude adjustment has been indicated by Osterberg[4], who separates the vibrations of dioptric and diffracted light by a cut and reassembled 'Polaroid'.

In all these systems[5] it is essential that the composite plate used be of equal optical thickness over its whole surface. We believe that this condition is more easy to obtain and to control for birefringent mica or 'Cellophane' sheet than for 'Polaroid'. A variable change of phase could be achieved in our design by replacing the quarter-wave plate by a Bravais compensator.

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Recording Crevices in Plane Surfaces by Pigment-fillings Held in Cellulose Acetate Moulds

In extending work on the recording of low relief in etched or abraded plane surfaces of rocks, minerals and metals by means of cellulose acetate moulds[1], it has been found that the forms and distributions of narrow structural crevices and microscopic pits in these and similar surfaces can be accentuated, for detailed study, by filling them with a suitable pigment which is then removed by, and retained in, the thin cellulose acetate moulds made from these prepared surfaces (Fig. 1). For this purpose a dispersion of cellulose acetate in tetrachloroethane is convenient. Addition of an appropriate plasticizer to the dispersion minimizes the development with time of very slight shrinkage and brittleness in the resulting moulds.

Fig. 1

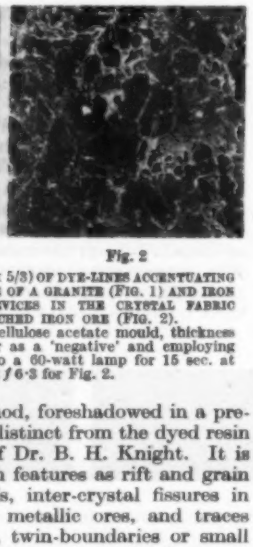

Fig. 2

PHOTOGRAPHIC ENLARGEMENT (× 5/3) OF DYE-LINES ACCENTUATING 'RIFT' IN THE POLISHED SURFACE OF A GRANITE (FIG. 1) AND IRON OXIDE-AREAS EMPHASIZING CREVICES IN THE CRYSTAL FABRIC OF A POLISHED AND ETCHED IRON ORE (FIG. 2).
Each print was made from a cellulose acetate mould, thickness 0·08 mm., used in an enlarger as a 'negative' and employing Kodak *B.G.*-4 paper exposed to a 60-watt lamp for 15 sec. at *f* 8 for Fig. 1 and *f* 6·3 for Fig. 2.

This pigmentation method, foreshadowed in a previous communication[2], is distinct from the dyed resin impregnation technique of Dr. B. H. Knight. It is suitable for recording such features as rift and grain in granites, cleat in coals, inter-crystal fissures in well-crystallized rocks or metallic ores, and traces of cleavages, glide-planes, twin-boundaries or small shallow etch-pits in the surfaces of individual mineral crystals. Further, it may prove to be useful in studies of crazing on glazed pottery and the crystal fabrics of certain alloys. Experiments suggest the most satisfactory records obtained by this method are derived from crevices or pits varying in width between 1 μ and 10 μ.

The pigment can be a solid dye, such as 'Soluble Blue 3*M*' or lampblack, or a liquid such as Indian ink. If a powdered pigment is used, the etched surface is cleaned and sprinkled with either finely divided dye or lampblack, which is then introduced into the crevices with the ball of the thumb, or a pad of soft cloth. If Indian ink is employed, on the other hand, it is washed over the cleaned surface with a camel-hair brush, and the excess removed, after a moment, with a pad of absorbent cloth; the use of cotton-wool is inadvisable as it tends to sweep cotton fibres into some of the surface crevices. Whether solid or liquid pigment is used initially, a careful rotary polishing movement with a suitable cloth removes it from the surface, while leaving it undisturbed in the crevices. The surface is then ready to receive the necessary thin layer of dispersion from which a pigmented cellulose acetate mould solidifies.

It is noteworthy that no significant spreading of pigment takes place in the dispersion-layer provided (*a*) the pigment used is not soluble in tetrachloroethane and (*b*) the dispersion-layer is thin. In connexion with (*a*), lampblack is a convenient pigment, apart from its relative chemical stability and its opacity in thin layers.

'Automatic' pigmentation of polished and etched surfaces of certain iron ores and iron-bearing meteorites[2] can be developed by exposing them to moist air for such a time that they become covered with thin films of hydrated iron oxides which can then be stripped from these surfaces in cellulose acetate moulds. By this means the forms and distributions of narrow fissures in the surfaces are recorded either as unpigmented bands, or as dark red-brown lines cutting the lighter brown limonite-bearing areas of the moulds (Fig. 2). Equivalent pigmentation can be obtained by developing thin films of copper carbonates on the polished and etched surfaces of some copper ores.

Finally, direct comparisons can be made between any pair of pigment patterns by superposing the necessary cellulose acetate moulds on an illuminated tracing desk, or by projecting them in a lantern or epidiascope, while photographic prints of any of the patterns can be made with ease by using the corresponding mould in the role of a photographic negative.

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[1] Dollar, A. T. J., *Geol. Mag.*, **79**, No. 4, 253 (1942).
[2] Dollar, A. T. J., *Nature*, **152**, 248 (1943).

Photometric Measurement of Specific Surface

In the course of measurements of the light transmission of dispersions of fine alumina powder in aqueous media, it has been found in these Laboratories that the effective projected area per unit weight of the powder gives a fairly good straight line of negative slope when plotted against the fourth power of the wave-length of the incident light. The projected areas were calculated from the usual formula:

$$A = \frac{\log_e I_0/I}{KCt},$$

where A is effective projected area; I_0 is intensity of incident light; I is intensity of emergent light; K is opacity factor of powder; C is concentration of powder by weight per unit volume; and t is path-length.

The measurements were made over the visible range with a photo-electric apparatus having a very low angle of acceptance (about 0·0001 ster radian), the opacity factor of the powder being assumed equal to unity. Extrapolation of the graph of A against wave-length to cut the axis of A yields a value of the projected area, A_∞, for which the wave-length is very small compared with the particle size. In such cases it has been shown by Sinclair[1] that the effective projected area is equal to twice the geometric projected area A_G owing to diffraction and scattering.

The specific surface of particles in random motion is usually considered to be equal to $4A_G$, 4 being the ratio of surface to projected area for a sphere. However, the crystals of calcined alpha-alumina may to a first approximation be considered as flat rectangular plates, and hydrated alumina crystals are roughly

cubical. It can be shown that the ratio of surface to projected area for a rectangular parallelopiped in random motion is $18\pi/(8+\pi)$ independent of the relative lengths of the axes, that is, whether the particle is flat, cubical or elongated. If this factor is used to compute the specific surface of calcined and hydrated alumina from the values of A_0 $(= 2A_G)$ found by graphical extrapolation, very good agreement over a wide range of samples is obtained with other estimates of the specific surface from air-permeability, sedimentation, and microscope data, if allowance is made for the flat shape of the calcined alumina crystals in the last two instances.

It thus appears that this method, which is rapid and economical of sample material, is capable of giving a good estimate of the specific surface of alumina powders over a wide range of values (1,000–40,000 cm.²/gm.), and may find application to other transparent crystalline materials. The extrapolation method of evaluating A_0 seems to overcome the difficulty due to unknown variations in opacity factor with particle size.

If the Hilger Spekker absorptiometer, having a relatively large angle of acceptance, is employed for the measurement, the value of the specific surface has been found to be approximately $4A_0$, instead of $2{\cdot}55A_0$. This result is no doubt fortuitous, and may be ascribed to the fact that some of the light refracted or scattered out of the parallel beam by the particles is still capable of striking the sensitive surface of the photocell, thereby reducing the estimate of A_0.

It is hoped to publish a more detailed account of this work at a later date.

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[1] *J. Opt. Soc. Amer.*, **37**, (6), 475 (1947).

Luminescence Efficiency Changes in Zinc Sulphide Phosphors Below Room Temperature

At temperatures below those at which thermal quenching of luminescence occurs in zinc sulphide phosphors (as shown by the higher temperature forms of the curves of Fig. 1), there is often a slow temperature variation of the luminescence efficiency. The sign of the temperature coefficient of this variation may be positive or negative, being dependent on the wavelength of the exciting radiation. Typical efficiency

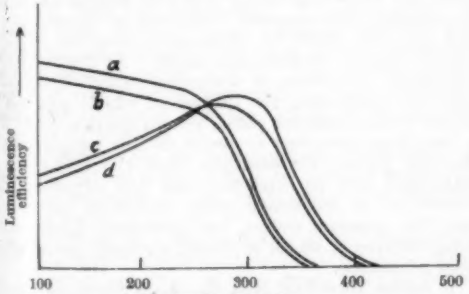

Fig. 1. Luminescence efficiency *vs.* temperature variation for ZnS–Zn phosphor. λ_{exc} for the four curves are: (*a*) 2537 A.; (*b*) 3132 A.; (*c*) 3653 A.; (*d*) 4043 A.

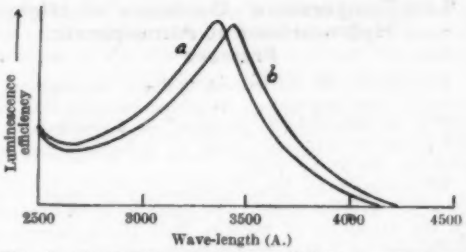

Fig. 2. Excitation spectrum of ZnS–Zn phosphor at (*a*) 90° K., (*b*) 230° K.

temperature curves for a self-activated zinc sulphide phosphor are given in Fig. 1 for different excitation wave-lengths. This behaviour has been previously observed by Schön[1], and recently Williams and Eyring[2] have attempted to explain it in terms of the intrinsic luminescence centre configurations. Their treatment gives a slow rise in efficiency with temperature, of an exponential form for longer wave-length excitation; but it cannot explain the fall in efficiency with temperature at shorter wave-lengths.

We have made measurements of the excitation spectra, that is, the variation of efficiency of luminescence excitation with wave-length of the exciting radiation, of various specimens of zinc sulphide phosphors. In particular, studies of the change in these spectra with temperature have been made. Spectra measured at two different temperatures for a typical self-activated zinc sulphide phosphor are shown in Fig. 2. By comparison of the curves of Figs. 1 and 2, it is found that the temperature shift of the excitation spectra (Fig. 2) can account for the slow rise or fall of luminescence efficiency over the same temperature range at various wave-lengths (Fig. 1). We have measured the temperature shift in A./° K. of the excitation spectra of typical phosphors and find that it is the same as the temperature coefficient for the absorption edge shift in these phosphor types as measured by Gisolf[3]. A theoretical study due to Möglich and Rompe[4] has shown that the absorption edge shift with temperature agrees with that expected from the known thermal expansion of the phosphor crystal lattice.

The accompanying table gives a comparison of values for temperature coefficients of the absorption edge shift measured by Gisolf, and the shift of the excitation spectra from our measurements between 90° K. and 290° K.

Phosphor	Absorption edge shift (Gisolf)	Temperature coefficients. Excitation spectrum shift (our measurements)
ZnS–Cu	0·425 A./° K.	0·5 ± 0·05 A./° K.
ZnS–Ag	0·45 A./° K.	0·5 ± 0·05 A./° K.
ZnS–Zn	—	0·5 ± 0·05 A./° K.

It is concluded from the above experimental studies that the thermal expansion of the phosphor crystal lattice and its effect on the impurity centres responsible for emission, which are dispersed in the lattice, can cause the above efficiency versus temperature variations and their changes with wave-length of exciting radiation.

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[2] Williams, F. E., and Eyring, H., *J. Chem. Phys.*, **15**, 289 (1947).
[3] Gisolf, J. H., unpublished work (1938) quoted in ref. 4.
[4] Möglich, F., and Rompe, R., *Z. Phys.*, **119**, 472 (1942).

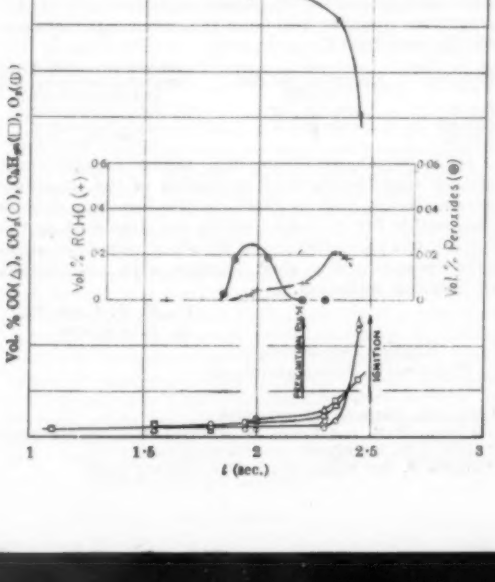
'Low-Temperature' Oxidation of Higher Hydrocarbons at Atmospheric Pressure

RECENTLY, we carried out ignition experiments in a Moore-type apparatus. Working between 300° and 500° C. at atmospheric pressure, we investigated the behaviour of *n*-heptane and an *n*-heptane–benzene mixture (50/50 by vol.).

With *n*-heptane, ignition was found to be preceded by a 'pre-ignition pulse'. The pulse could be observed by the expulsion of vapours from the apparatus or registered on a manometer connected to the apparatus. Three temperature regions could be distinguished. (1) Above 400° C., the delay between pulse and ignition was too short to be measured, so that ignition occurred apparently by a single-stage mechanism. (2) Between 316° and 400° C., the pre-ignition pulse was followed after a measurable time-interval by ignition. We measured both the time interval, τ_1, between the start of the reaction and the pre-ignition pulse, and the time interval, τ_2, between the pulse and ignition. In agreement with the observation of Sokolik and Jantovski[1], τ_1 decreased continuously with increasing temperature, while τ_2 passed first through a minimum and then through a maximum. (3) Below 316° C., no ignition could be observed, yet the pulse still occurred, down to a temperature of about 300° C., τ_1 increasing with decreasing temperature.

With the *n*-heptane–benzene mixture, again three temperature regions were observed: (1) above 425° C., ignition occurred apparently by a single-stage mechanism; (2) between 370° and 425° C. only slow oxidation occurred, without any physical manifestation such as a pressure pulse or ignition; (3) between 305° and 370° C. the pressure pulse occurred, without being followed by ignition. Only at 340° C. and pressures slightly higher than atmospheric was the pulse followed by ignition.

We collected gas samples corresponding to different stages of the reaction. The samples were analysed for oxygen, carbon monoxide and dioxide, unsaturated hydrocarbons, peroxides, aldehydes and oxides of nitrogen. The peroxides were determined with acid potassium iodide, sensitized with ammonium molybdate. Ferrous sulphate was ineffective as sensitizer. This leads us to the conclusion that the peroxides determined were of the alkyl hydrogen type[2], and probably secondary alkyl hydrogen peroxides. The concentration of oxides of nitrogen found was about 1 per cent of the concentration of peroxides, so that the measured value of the latter could be only slightly affected by the amount of nitrogen dioxide present.



A typical set of results, obtained for *n*-heptane at 345° C., is reproduced in the accompanying graph. Generally, we found that a peroxide maximum was followed by an aldehyde maximum, thus establishing the fact that aldehydes are products of the decomposition of peroxides. We found, further, that the pre-ignition pulse coincided with a decline of the concentration of peroxides.

We examined the experimental material in the light of existing theories. In agreement with the views expressed by Walsh[3], we concluded that initiation occurred through the formation of secondary alkyl radicals, leading to secondary alkyl hydrogen peroxide radicals and to secondary alkyl hydrogen peroxides. Decomposition of the latter according to

$$\begin{matrix} R\,\mathrm{CH}\,R \\ \mathrm{O} \\ \mathrm{O} \\ \mathrm{H} \end{matrix} \rightarrow R\mathrm{CHO} + R. + .\mathrm{OH} \qquad (1)$$

seems to agree with the magnitude of the pressure pulse registered on the manometer.

The mechanism of the chain reactions following the pressure pulse is still a matter of conjecture, since no intermediate products have so far been isolated. We concluded that a combination of the reaction schemes proposed by Lewis and von Elbe[4] and by Ubbelohde[5] may present a reasonable explanation. At high temperatures, degradation reactions may prevail, *R*CHO decomposing according to the scheme proposed by Lewis and von Elbe, and *R*·, after peroxide formation, according to the scheme proposed by Ubbelohde. At lower temperatures, oxydialkyl peroxides may be formed, the decomposition of which leads to a branching reaction[4]. The tendency to follow slower degradation reactions at higher temperatures, as opposed to branching reactions at lower temperatures, would thus be responsible for the negative temperature coefficient of the overall reaction in the 'low-temperature' region.

Recently, Walsh[6] severely criticized the reaction schemes proposed by Lewis and von Elbe. The decomposition of secondary alkyl hydrogen peroxides is said to be responsible for the branching reaction, while the instability of the peroxide radical explains the negative temperature coefficient of the reaction. The evidence which we obtained during our experiments does not support this theory. At 316° C. with *n*-heptane we found a secondary alkyl hydrogen peroxide maximum, the decline of which was associated with a pressure pulse, yet no ignition (that is, a branching reaction) occurred at this temperature. We also found, for example, that the addition of tetraethyl lead to *n*-heptane did not suppress the formation of secondary alkyl hydrogen peroxides and the pressure pulses, but prevented ignition at temperatures at which it would normally occur with pure *n*-heptane.

It seems, therefore, that the chain reactions which follow the decomposition of the secondary alkyl hydrogen peroxides in the 'low-temperature' region still await a reasonable explanation.

A full account of our work will be published elsewhere.

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[1] Sokolik, A., and Jantovski, S., *Acta Phys. chim. U.S.S.R.*, **19**, 329 (1944).
[2] Egerton, A. C., Smith, F. L., and Ubbelohde, A. R., *Phil. Trans. Roy. Soc.*, A, **234**, 433 (1935).
[3] Walsh, A. D., *Trans. Farad. Soc.*, **42**, 269 (1946).
[4] Lewis, B., and von Elbe, G., "Combustion, Flames and Explosions" (Cambridge, 1938).
[5] Ubbelohde, A. R., *Proc. Roy. Soc.*, A, **152**, 354 (1935).
[6] Walsh, A. D., *Trans. Farad. Soc.*, **43**, 297 (1947).

Economy in Cell Counts

IT is often necessary in clinical work to determine the relative abundance of two or more species of cells. Examples are counts of the percentage of atypical cells, such as reticulocytes, siderocytes or punctate basophilia, in the blood erythrocytes. In these cases the required result, F, is a fraction. If P and Q are the numbers counted of the two types of cell, $F = P/(P + Q)$. In other estimations, such as the 'platelet ratio', or the proportion of megakaryocytes to nucleated white cells in a marrow smear, the required result is a ratio, $R = P/Q$. F cannot exceed unity, while R may have any numerical value.

The frequencies of the two species of cells are often widely different, making it necessary to count thousands of the common type to include a moderate number of the rarer. The questions arise, Can one save time and labour by counting the abundant cells in a fraction $1/a$ of the area sampled for the rarer type? What would be the precision of a value of F or R so obtained? And what are the best values of P and Q to secure a desired precision with a minimum amount of counting?

There are various algebraically equivalent formulæ for the standard deviation of a ratio or a fraction. The forms most useful for the present purpose are

$$\frac{\text{Standard deviation of } R}{R} = \sqrt{\frac{1}{P} + \frac{1}{Q}} \quad . \quad (1)$$

$$\frac{\text{Standard deviation of } F}{F\,(1 - F)} = \sqrt{\frac{1}{P} + \frac{1}{Q}} \quad . \quad (2)$$

Now it can be shown that when P and Q are sampled on different scales, so that $R = P/aQ$ or aP/Q, and $F = P/(P + aQ)$ or $aP/(aP + Q)$, formulæ 1 and 2 are still true and applicable. It can further be proved that, for any given value of the standard deviation, the number of cells required to be counted is a minimum when $P = Q$. Hence the simple practical rule: choose that value of $1/a$ which will make the counts of the two kinds of cell as near equality as possible.

It is easy to see the commonsense justification of this rule. There is no point in laboriously measuring Q to an accuracy of 1 in 1,000 when P is accurate only to within 1 in 10.

When there is a big disparity in the frequencies of the two kinds of cell, the time saved by this method of 'balanced sampling' is very great. For example, in blood containing 2 siderocytes per 1,000 red corpuscles, a count of 80 cells by balanced sampling will give an answer as precise as a direct count of 10,000 cells. In general, if a is chosen to make $P = Q$, the total number of cells to be counted in balanced sampling is the fraction $4a/(a + 1)^2$ of the number needed in a direct count, for the same precision of estimate.

This method has the further advantage that a count of a given size always yields an estimate with approximately the same relative precision. One can therefore work out once and for all the numbers to be counted for any desired limits of significance, and choose the appropriate size of count for each particular purpose. There will then be no need to calculate standard deviations and significances of differences separately for each estimate.

I am publishing elsewhere a full account, giving details of the practical use of the method in cell counting. It is obvious that balanced sampling has many other uses. The technique here described is a special application of a general theory of weighted and stratified sampling, to be published elsewhere.

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Empirical Data on Hilbert's Inequality

IT is known that

$$\sum_1^\infty \sum_1^\infty \frac{a_r a_s}{r + s - 1} \leqslant \pi \sum_1^\infty a_r^2,$$

π being the best possible constant, and it has recently been shown by H. Frazer[1] that

$$\sum_1^N \sum_1^N \frac{a_r a_s}{r + s - 1} \leqslant \left(N \sin \frac{\pi}{N}\right) \sum_1^N a_r^2.$$

Frazer's result, however, is not the best possible, as may be seen from the numerical data below, in which λ is the maximum value of

$$\sum_1^N \sum_1^N \frac{a_r a_s}{r + s - 1}$$

for a normalized vector a_r. We are indebted to the Royal Aircraft Establishment, Farnborough, and to Mr. Fairthorne for the computation of these data.

N	λ		
1	1		
2	1·267	591	879
3	1·408	318	927
4	1·500	214	280
5	1·567	050	691
10	1·751	919	657
20	1·907	134	681

Approximate relations of the form

$$\frac{1}{\pi - \lambda} = a \log (N + b) + c$$

can be obtained to fit these data, with errors at the most of 0·001 up to $N = 10$, but an error of 0·005 for $N = 20$. It is evident from the behaviour of the errors that the formula is incomplete.

The values of λ for all values from 1 to 20 are at present being calculated for us at the National Physical Laboratory. The results will be published as soon as available.

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[1] *J. Lond. Math. Soc.*, **21** (1946).

EARLY HISTORY OF THE ROYAL BOTANIC GARDEN, CALCUTTA

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A GENERAL account of the Royal Botanic Garden, Calcutta, has been given by Biswas[1], and some of the detailed incidents connected with the formation of the Garden are also available in the published papers by Anderson[2] and King[3]. The Calcutta Garden is perhaps one of the oldest gardens in Asia, and it is not generally realized that it was established by the Honourable East India Company as early as 1787, essentially for the purpose of increasing the commercial riches of the Company, and *not* for the advancement of botanical knowledge in India and elsewhere. It was cleverly planned by an army officer, and the proposal was so attractive to the directors of the Company that they readily agreed to the establishment of such a garden. The detailed correspondence on the subject is preserved among the old records of the East India Company. This was made available to me through the courtesy of the Keeper of Records, India Office, London. Some of these letters have been published both by Anderson[2] and King[3], and it is not intended, therefore, to re-publish them here. The remainder of the letters afford other valuable and interesting information, and the purpose of this note is to reveal some of the lesser known facts regarding the origin and development of this garden.

Unfortunately the exact date on which the Garden was started is not clearly known. Carey[4] says that it was started in March 1786—a statement which seems to be wrong from an examination of the correspondence, and which has been corrected by Anderson. Prior to the official sanction by the East India Company, part of the Garden existed around the country house of Lieut.-Colonel Robert Kyd. This plot of land formed the eastern part of the Botanic Garden after its formation and has been referred by Roxburgh[5] in connexion with a tree—*Garcinia cornea* Willd. The actual proposal for the establishment of a botanical garden near Calcutta was submitted to the then Governor-General (Sir John Macpherson) at Calcutta by Lieut.-Colonel Kyd on June 1, 1786[6]. It was clearly stated in this letter that the idea of establishing a botanic garden is "not for the purpose of collecting rare plants as things of mere curiosity, but for establishing a stock for disseminating such articles as may prove beneficial to the inhabitants as well as to the natives of Great Britain, and which ultimately may tend to the extension of the national commerce and riches". It was suggested that the proposed garden would grow teak for ship-building, various spices (such as cinnamon, cardamon, clove, black and white pepper and nutmeg) for sale in Europe, and other articles of commerce (such as cotton, tobacco, indigo, coffee, camphor, gum-yielding plants and tea). The proposal was duly supported by the Governor-General, who wrote by way of recommendation to the Directors of the East India Company, "the garden may be formed as a general plantation or nursery where the cultivation of the cinnamon and the different articles mentioned by Col. Kyd may be attempted". The cost of maintaining this garden was suggested by Kyd at the low figure of Rs. 150–200 per month[7].

Kyd derived this inspiration, which led to the suggestion of forming a botanic garden, possibly from two sources: (1) in the garden of the previous Governor-General (Warren Hastings), he found some flourishing cardamon trees growing, and also some natural seedlings which promised a "rising plantation"; (2) Kyd himself was a keen gardener and at that time collected and grew, in the compound of his country house at Salimar, many foreign plants of economic and horticultural value. He used to secure these plants from the captains of the Company's ships returning from voyages to the Far East. Hence, his own experience had convinced him that some of the spices of the East Indies could be grown in India. If this could be achieved, it would have a further advantage, namely, the Dutch monopoly of the highly prized cinnamon and other spices would be broken.

The Court of Directors, too, as clever business heads of a commercial organisation, were alive to the benefits of this scheme. In their letter of approval, dated July 31, 1787, they duly stressed among other things the cultivation of cinnamon. This portion of their letter runs, "The experiment respecting the cinnamon tree in particular must be made in different parts and soils of those extensive provinces in order to ascertain with certainty whether this spice can be produced in Bengal equal to that which grows on the island of Ceylon[8]. We are aware that by extending your experiment too far, the expenses may increase to an amount of which you may not at present have any idea. But so sensible are we of the vast importance of the objects in view, that it is by no means our intention to restrict you in point of expense in the pursuit of it. In the cultivation of cinnamon tree in particular, we foresee a great source of wealth to the Company and of population and opulence to the provinces under your administration. Most earnestly therefore do we recommend it to you to proceed in your endeavours to propagate this spice in different places, and that you avail yourselves of the abilities and zeal of Lieutenant-Colonel Kyd herein."

The next step was the selection of a site and the acquisition of the land. This presented some difficulties. In his letter dated August 10, 1786, Kyd said that he, in company with a Mr. Hay, examined a plot of ground on the western bank of the river in the vicinity of Calcutta. One area which seemed suitable was not available, as on inquiry from Mr. Jonathan Duncan, the revenue officer, Kyd learnt that the ground had been allotted to the followers of Tishore Lama of Tibet, and had been consecrated for religious purposes. Kyd had of necessity to forgo this plot and chose a second area where the fort of Muggah Tannah and the barracks of the Moorish garrison formerly stood. This fort fell to the British under the leadership of Clive at the time of recapture of Calcutta. It was then demolished by mining. The condition of part of this ground was stated to be "perfect wild, overgrown with brush wood and subject to the overflow of the tide". This ground was adjacent to a plot of land which Kyd already possessed, and where he had his country house with his garden. A portion of this area fell within the limits of the Burdwan district (the extended limit of that time), and the Burdwan land was acquired from the Zamindar by exchanging an equivalent portion of East India Company's land elsewhere. Other lands of the Company, measuring 148 *bighas* 9 *cottahs*, were given to the residents of the ground, to induce them to leave the area, and the amount of compensation granted to them for their huts and personal effects was Rs. 3,166/4/0.

Having obtained the ground, Kyd with 109 labourers started to dig a ditch round the plot of land and also erected a fence. The fence was necessary to exclude wild buffaloes, which frequently visited the area. The monthly cost of this work, excluding the bamboo fencing, amounted to Rs. 384/0/0, and the work must have taken several months, for we read in a letter of the Treasury Officer (Buxey), dated May 1, 1787, that Kyd has drawn "one thousand sicca rupees" for this purpose. This amount appears to be only an instalment.

Those readers who have visited the Royal Botanic Garden, Sibpur, Calcutta, will recall that the ditch made by Kyd still exists, and is fairly continuous around the Garden, even now. A part of the ditch, that is, the ditch which now separates the Bengal Engineering College from the Botanic Garden, existed earlier, as this ditch formed part of the boundary of the old fort of Muggah Tannah. The portion of land, east of this ditch, that is, part of the present area of the Bengal Engineering College, was Kyd's personal land. This was given (at least, the major part of it) to the Botanic Garden at the time of its formation (1786–87), and remained so until 1820. In that year the same portion was given to the Lord Bishop of Calcutta for the establishment of a College. It appears that this old ditch of Muggah Tannah thus formed a ditch of convenience at the time of handing away a part of the garden land for the purpose of Bishop College, and the same holds good as a good demarcating line even now. The original ground of Kyd's garden house was known under various names, such as Kyd's Garden, Royd's Garden, Barwell's Garden, and in 1819 as Metcalf's Garden.

The next stage was to lay out the Garden and to start the commercial plantation of cinnamon and other spices. In this, Kyd was unusually ambitious but he was never a botanist. These two facts led to the complete failure of the enterprise after a few years of experiment. His ambitious aspect is evident from the fact that he wanted to grow every desirable economic plant of every country in his Garden. By a voluminous correspondence with British agents in different parts of Asia, he secured an amazing variety of plants, such as Persian dates, Persian tobacco, Chinese tea, oranges, English apples, cherries, apricots, sandalwood from the Malabar coast, and other plants like black pepper, bread-fruit, and a number of gum-producing plants. All these were duly planted out; but, as was to be expected, most of them perished in the uncongenial climate and soil of Calcutta. The cultivation of teak was also abandoned for the same reason in later years[11].

Kyd's term of honorary superintendentship of the Company's Botanic Garden was not a long one. His failure to grow so many commercial and economic plants should not be regretted by the present botanists of India, as his success (if it could have happened) might have altogether changed the destiny of the Garden. It appears to me that by his failure he paved the way to a botanic garden, which in the hands of his able successor played a very important part in the advancement of Indian botany. The name of Kyd should, however, be remembered with reverence as the founder of the Calcutta Garden which was destined to become a botanic garden and not a cinnamon plantation of the tea-garden type, on which so much stress was laid from the beginning, and at every stage.

Kyd died on March 26, 1793, and was buried in the South Park Street Cemetery in Calcutta. Two years later a memorial was erected in the Botanic Garden and a marble urn was placed on it. The site for this memorial was selected by Roxburgh[9], and the inscription on the urn says, "To the honour of Robert Kyd, an officer of the army and founder of this garden; placed by A. K. 1795" ("Roberto Kyd, *mil. trib. horti foundatori posuit A. K.*, MDCCXCV"). The initials A.K refer to his relation, Alexander Kyd, who was then a major in the Bengal Engineers, and who later constructed the Kidderpore docks.

Kyd was succeeded by Dr. William Roxburgh, who on November 29, 1793, was appointed the first salaried superintendent of the East India Company's Botanic Garden. It was Roxburgh who got a sanction of Rs. 15,000 to build quarters for the Superintendent. This house was completed after 1795, and Roxburgh's request for a further sum of Rs. 5,000 (presumably over-spent in building the house) was refused by the Company. This house is a three-storied building on the river-bank and is still occupied by the Superintendent of the Garden.

During and since Roxburgh's tenure of office, the Botanic Garden near Calcutta has attracted the attention of the scientific world, and the scientific study of Indian plants dates from his time. (A few years prior to Roxburgh, Dr. Koenig was in India. Roxburgh regarded him as an intimate friend and also his preceptor. Koenig was essentially a plant collector who sent his plants to Linnæus (father and son) and Retzius.) Roxburgh has been, therefore, rightly called the 'father of Indian botany'.

It will be easily understood that, under the direction of a man of science such as Roxburgh, devoted to the scientific study of Indian plants, the original aims of the Garden as emphasized by the directors of the Company were not followed. Much about the same time the East India Company was being gradually eclipsed by the British Government. This was being done through the provisions of Pitt's India Act, and as such the control over Roxburgh became less and less effective. This allowed him to carry on as he liked.

For official purposes, the date of actual sanction to the proposal of establishing a botanic garden by the court of directors of the East India Company (that is, July 31, 1787) should be regarded as the beginning of the Garden. Prior to this date only a part of the Garden existed around Kyd's country house, which was included later within the botanical garden compound in 1787. On the basis of this date, the Royal Botanic Garden, Calcutta (as it is now known), completed its 150th year on July 30, 1937, and this was celebrated in a fitting manner on January 6, 1938. The latter date was apparently fixed for the sake of convenience only, as many British and foreign men of science, including the Director of the Royal Botanic Gardens, Kew, happened to be present in India at that time.

The East India Company during the years 1786–87 governed the country, collected the revenue, and administered law and order. Yet constitutionally its position was like that of landlord under the Nawab of Bengal. The Company at that time was still a private trading company, and could not be regarded as a part of the British Government. Robert[10] says, "the constitutional relation between the Nawab of Bengal and the East India Company at that time was indeed complicated. The Company secured the administration of military power and criminal justice (*Nizamat*) from the Nawab, and the power to collect revenue and administer civil justice (*Diwani*) from

the Moghul Emperor." The above statement clearly shows that the East India Company was actually ruling the country under the shadow of the Nawab of Bengal. The Nawab was relieved of this heavy responsibility, as he got annually more than 40 lacs of rupees from the Company as lease-money. This position was cleverly stated by Clive thus, "the Nawab had only the name and shadow of authority, yet this name . . . this shadow, it is indispensably necessary that we should venerate".

This relationship should be clearly understood, as this represented the last days of the Moghul period, a dark period of the East India Company, and the formative phase of the British rule. Unless this is understood, one is liable to assume that the East India Company really represented the British Government at that time.

[1] Biswas, K., "150th Anniversary Volume of the Royal Botanic Garden, Calcutta", 2–12 (1942).
[2] Anderson, T., *J. Agric. Hort. Soc. India*, N.S., **1**, 169 (1869).
[3] King, G., *Ann. Roy. Bot. Gard., Calcutta*, **4**, Pt. 1, i–xi (1893).
[4] Roxburgh, W., "Hortus Bengalensis", **2** (1814).
[5] Roxburgh, W., "Flora Indica", **2**, 629 (1832).
[6] This date is given as January 1, 1786, by Biswas (*l.c.* 2). This is probably a printer's error.
[7] An idea of the present-day cost can be formed from the amount spent in 1944–45, which was Rs. 1,20,928.
[8] At that time Ceylon was under the Dutch Government.
[9] Biswas' statement on this point is contradictory (*l.c.* 2). King says (*l.c.* 3) that this site was selected by Roxburgh and not by Kyd himself, as stated by Biswas.
[10] Robert, P. E., "Historical Geography of the British Dependencies", **7**, India, Pt. 1 (1916).
[11] King, *l.c.*, iii.

TRACE ELEMENTS IN PLANT PHYSIOLOGY

UNDER the auspices of the International Union of Biological Sciences, a symposium on "Trace Elements in Plant Physiology" was held at Rothamsted Experimental Station, Harpenden, under the chairmanship of Prof. B. Nemec, of Prague, during November 5 and 6, 1947. Representatives from many countries attended.

The symposium was conducted in four sessions, at which fourteen short papers were read to introduce the subjects for discussion. The work in progress on trace elements under Drs. Winifred Brenchley and Katherine Warington at the Rothamsted Station was inspected at the end of the meetings.

On the evening of November 6 the members of the conference were entertained at an after-dinner function at the Rothamsted Laboratories by the Director, Dr. W. G. Ogg, and the staff of the Station, when the delegates met senior members of Rothamsted concerned with trace-element investigations.

The subjects presented in the papers for discussion covered a wide field and included items of current scientific interest and practical importance, and demonstrated the immense value of plant physiological studies in investigating problems of crop production and animal husbandry.

Prof. Nemec, in his opening address, outlined the development of methods of research on trace elements, referring in particular to the early water culture experiments of Sachs and the influence of Prof. Stoeckard, of Tharandt Forestry School, Saxony, on this pioneer work. He exhibited a sample of gold obtained from the ash of plants of *Equisetum palustre* grown on volcanic soils in Bohemia, and referred to the concentration of droplets of metallic mercury in the seed capsules of *Holosteum umbellatum* on some soils.

Prof. T. Wallace and Dr. E. J. Hewitt (Great Britain) outlined methods in use in trace-element research at Long Ashton. It was shown how visual methods can be applied to problems of deficiencies, excesses and relationships of trace elements in plant nutrition studies, and how the method can be applied to analyse the injurious effects of soil acidity. Dr. Hewitt described his technique for large-scale sand cultures by means of which he has been able to study problems relating to deficiencies of iron, manganese, boron and molybdenum. The various points of these two papers were illustrated by a comprehensive exhibit of photographs.

Prof. J. Lavollay (France) outlined his method for the determination of the coefficient of action of mineral nutrients and illustrated the application of the method to problems concerning magnesium nutrition, showing how yield is related not only to the supply of magnesium in the nutrient, but also to the total concentration of salts in the medium. He demonstrated the beneficial effect of phosphorus on the action of magnesium and the antagonism which exists between magnesium and potassium; also the similarity of action of potassium and rubidium.

Dr. D. I. Arnon's (U.S.A.) contribution concerned the criteria of essentiality for micro-nutrients, and he illustrated his points by reference to his investigations in California on the essential role of molybdenum in plant nutrition. He suggested as the three criteria of essentiality of any element: (1) the life-cycle of the plant cannot be completed if the element is omitted; (2) the action of the element must be specific; (3) the effect on the plant must be direct. The paper and the discussion revealed the great practical difficulties of establishing 'essentiality' for elements required only in traces; but nevertheless it was thought that refinements of methods might disclose the essential nature of further elements.

Points of special interest in trace element nutrition were discussed in papers by Dr. E. G. Mulder (Holland), Dr. J. Erkama (Finland), and Prof. H. Burström (Sweden). Dr. Mulder described experiments concerning the functions of copper and molybdenum in the metabolism of higher plants and micro-organisms, and also referred to the application of his results to field crops in the Netherlands. Copper is regarded as a catalyst of oxidation processes, and molybdenum has been shown to be necessary for the reduction of nitrate nitrogen in higher plants and for the fixation of nitrogen by *Azotobacter*.

Dr. Erkama in his studies has regarded the three elements iron, manganese and copper as comprising one unit, and has endeavoured to determine their relationships. Manganese seems to be antagonistic to both copper and iron, and reactions with manganese seem to take place mainly in the vacuole sap. Copper, it is suggested, is able to remove iron from the vacuole sap and to oxidize it in protoplasm.

Prof. Burström reported results on the action of manganese in roots. Manganese appears to catalyse nitrate reduction in roots, and in this respect it may have a similar function to molybdenum in some plants. His results show that in roots, nitrogen increases the length of cells, phosphorus is concerned with cell multiplication, while manganese appears not to affect the ultimate length of the root. Manganese may shorten the meristem region, and while increasing the rate of root elongation it also shortens the 'grand period' of growth. Manganese thus seems to have effects apart from those concerned with nitrogen. Arising from this paper, the differential

effects of NH_4 and NO_3 with *Aspergillus*, excised roots and attached roots were discussed in relation to redox systems.

The practical application of trace element investigations to crop-producing problems was discussed in the contributions of Dr. L. Gisiger (Switzerland), Prof. F. Steenbjerg (Denmark), Dr. Marie P. Löhnis (Holland), Prof. E. A. Jamalainen (Finland), and Dr. D. Mulder (Wilhelminadorp; this last being communicated by Dr. Löhnis).

Dr. Gisiger described investigations relating to crop failures in Switzerland during the War resulting from over-liming associated with deficiencies of boron and manganese. From his experiments he concludes that the damage from excess liming is due to the hydrating action of the OH^- anion. Boron tends to counteract this effect by dehydrating action, this being an alternative hypothesis to the fixation of boron by lime action. The OH^- ion is regarded as causing the unavailability of manganese over an intermediate range of *p*H, availability increasing at low and high *p*H values. The range of low availability is similar to that shown by Quastel *et al.*, at which soil organisms are active in the oxidation of soil manganese.

Prof. Steenbjerg outlined the main problems of trace elements investigated in Danish agriculture. Iron and manganese deficiencies are common in horticultural crops and copper deficiency occurs in crops on the sandy soils of Jutland. Cobalt deficiency in cattle has also been recognized. Investigations have largely concerned deficiencies of manganese and copper. With manganese the problems differ for sands and clays, and soil methods have been devised for advisory purposes. Organic matter is an important cause of copper deficiency, and the availability is greatly influenced by preceding crops. Grass is regarded as important in mobilizing soil copper. The copper content of plants has been shown not to be an infallible guide in the diagnosis of copper deficiency, since when growth is severely stunted the total copper content of the plant material (as percentage dry matter) may not be unduly low. A characteristic S-shaped curve is obtained relating dry matter production and total copper content. Deficiency values occur up to the point of inflexion.

Discussion of this paper showed that many problems concerned in availability of manganese and its relations to other elements in plants, for example, Mn/N, require further study.

Dr. Löhnis described her researches on the toxicity of manganese to crops in acid soils in the Netherlands. *Phaseolus vulgaris* and *Vicia sativa* were found to be highly susceptible, whereas oats and strawberries were resistant to damage. Resistance to excess manganese and susceptibility to manganese deficiency (as shown by oats) cannot be explained on the simple basis of 'ease of absorption of manganese' from the soil, since some crops are susceptible (for example, *Phaseolus*) and others resistant (for example, strawberry) to both excess and deficiency of the element.

Prof. Jamalainen gave an account of the occurrence of deficiencies of boron, copper and manganese in crops of Finland. Boron deficiency is prevalent in sugar beet, swedes and apples, and occurs even on strongly acid soils, though the deficiency is accentuated by liming. Other crops affected are clover, celery, turnips and white mustard.

Copper deficiency is also an important problem, particularly on peats, but also on sands. Clay soils are less affected. Cereals, hay crops, potatoes and root crops have all responded to copper dressings.

As the soils of Finland are mainly acid, manganese deficiency is rare, though marsh spot of peas has been noted in Aland. The deficiency may occur on over-limed soils.

The contribution sent by Dr. D. Mulder concerned the occurrence of zinc deficiency in fruit trees in Europe and referred in particular to apples, pears and cherries in the Zeeland province of the Netherlands and to reported instances in apples in Hungary, Denmark and Switzerland. The Dutch examples occur on highly calcareous sands, and the deficiency can be cured by winter or summer sprays of zinc sulphate.

A novel paper of the symposium was contributed by Prof. L. Seekles (Holland), in that it referred to trace-element problems in farm stock. The contribution showed clearly the similarity in plants and animals of many of the fundamental problems concerned with trace elements. Thus in both there appear to be direct and induced (or 'conditioned') deficiencies, and relationships between elements may be of great importance. Moreover, as Prof. Seekles pointed out, trace elements are concerned with many linked series of enzyme reactions in plants and animals, and the breaking of these series at different points from different deficiencies may result in varied or similar pathological conditions.

At the conclusion of the conference, Dr. D. I. Arnon proposed that an endeavour should be made to adopt a term for universal use to replace the numerous current expressions used by different workers, namely, 'trace elements', 'trace nutrients', 'minor elements', 'oligo elements', 'spuren-elements'. He was prepared to suggest the term 'micro nutrient elements' as a basis for discussion and agreed to prepare a memorandum on the subject.

NEW ZEALAND DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

ANNUAL REPORT FOR 1946–47

THE twenty-first annual report of the Department of Scientific and Industrial Research, New Zealand (Wellington: Gov. Printer. 1*s.* 9*d.*), includes the Minister's statement, the secretary's report for the year 1946–47, reports of the various research committees and of the Cawthron Institute, as well as reports from branches and on research work at Canterbury and Massey Agricultural Colleges. The three main new activities noted by the secretary are the establishment of a Fuel Efficiency Service in an effort to reduce the consumption of coal in industry; the extension of the Information Bureau to deal more systematically with the exchange of information for scientific workers of the Department and the Dominion generally, and its dissemination among interested Departments and the public; and a start on the use of radioactive tracer elements in certain biological and chemical problems associated with soil processes. Building research included investigations on lightweight concrete and pumice concrete and the testing of properties of new materials, while the Plant Diseases Division examined the toxicity of wood preservatives and the treatment of infested buildings, as well as the testing of preservatives against fungi. The

Dominion Physical Laboratory undertook measurements of thermal transmittance on two types of concrete construction and also on a weatherboard house.

The work of the Dairy Research Institute was focused upon further improvement in the quality of New Zealand dairy products for export, reducing losses in manufacture, utilizing skim milk to the best advantage in feeding calves in New Zealand, and the influence of the plane of nutrition of the dairy cow during its normal dry period on the quality and quantity of milk produced in the subsequent lactation. The finding that cress-taint does not appear in the butter if cream from cows that have consumed cress is pasteurized below 180° F. was confirmed. Attempts were made to determine the relative influences of fat and casein on the moisture-holding properties of cheese-curd, while the Fats Research Laboratory established on April 1, 1946, initiated research on the nature of fats, particularly those occurring in dairy products.

Fruit cold-storage research covered the influence of root-stock and intermediate scion on core-flush in Granny Smith apples and the effect of a pre-harvest, fruit-fixing spray or superficial scald. Trials with 'Pliofilm' wraps in the shipment of oranges indicated that the percentage of sound fruit was substantially increased, but the high cost of the material outweighed the saving; use of paper wraps impregnated with diphenyl proved highly economic in reducing losses from fungous rots. Fruit research included manurial investigations and root-stock trials on apples, variety trials on apples, peaches and citrus fruit, investigations on codling moth control, tests on new products such as 'Gammexane', 'Dittane', 'Fermate' and 'Phygon', magnesium deficiency investigations, studies of the effect of penicillin on fruit fungi and of the control of black-spot of apples and pears with 'Elgetol' spray, raspberry investigations and a disease survey of orchards.

The Industrial Psychology Division made a survey of eye-strain in two clothing factories, and commenced an investigation into the adjustment of youth in industry as well as carrying out many vocational examinations. The Leather Research Association's studies of the quality of sole leather indicated that the wear life of a sole bears a definite relation to the amount of hide substance per unit area. Some of the fundamental properties of water-pigment finishes in use were examined, as well as difficulties experienced in curing and storing calf-skins. The Shoe Research Association commenced an investigation on the types of leather most suitable for insoles, and continued its work on the effect of perspiration on leather. The Fertilizer Manufacturers' Research Association drew up a programme of work and was selecting a site for its laboratory. The Pottery and Ceramic Research Association carried out preliminary work on the differential thermal analysis of New Zealand clays and completed preliminary work on a similar method for determining free quartz in clays. The Woollen Mills Research Association continued its control work on unshrinkable finishes, as well as further trials of 'Gammexane' against carpet beetles, and completed the mill tests on the manufacturing trial of hairy wool and the combing trial of exported scoured wool.

Under the Tobacco Research Committee, fertilizer experiments led to a general increase in yield, magnesium having a beneficial effect on both yield and quality. Surveys were made of both mosaic disease and black root-rot in the seedling beds of many growers, and experiments to control collar-rot continued, while the Cawthron Institute continued soil mapping of tobacco lands. Other work at the Cawthron Institute related to land utilization, soil analysis and investigations on tomatoes, including the treatment of soil with steam, formalin and chloropicrin, the effect of cocoa-bean husks, compost, etc., on yield, tomato 'cloud' and 'hard-core'.

Research work at Canterbury Agricultural College included sheep-dipping trials with *D.D.T.* and 'Gammexane', studies in copper deficiencies, on insect pests of wheat crops and on subterranean clover, as well as farm-machinery research, microbiological investigations of ear blight and frost damage, eyespot disease, the efficiency of commercial seed-wheat dusting and the seed disinfection of peas. At Massey Agricultural College studies on hairy sheep (N type) added to our understanding of the fleeces of both hairy and non-hairy sheep. Other work was concerned with the propagation of cuttings, drainage and the internal parasites of sheep, while the Biochemistry Department studied the wear of sheep's teeth and the milk supply of Romney ewes.

Since the reversion of the control of the geophysical work at the Apia Observatory to the Department, efforts have been made to provide modern buildings suitable for tropical conditions, modern equipment, adequate scientific staff and congenial living conditions.

The Auckland Industrial Development Laboratories report an increase in the number, variety and complexity of the industrial problems in which assistance has been sought, while the first annual report of the Biometric Section indicates that, in addition to facilitating basic statistical and biometrical control of agricultural trials, the Section was concerned mainly with the collection of an adequate library of technical literature, the recruitment and training of staff, the exploration of methods, such as the punched card technique, of handling extensive collections of data, as well as research and consultative work.

At the Dominion Observatory the method of controlling the standard clocks was unchanged, and the time-service arrangements were continued as previously, except for special time signals which had been sent out for war purposes up to January 31. The chief seismic event was the disturbance in the Lake Coleridge region on June 26; but 306 earthquakes were felt during the year in some part of New Zealand, 87 in the North Island and 219 in the South Island.

Lack of accommodation is still a great hindrance to the work of the Dominion Laboratory where, in addition to the examination of 25,103 samples, research was carried out on New Zealand woods, and special coatings were applied to experimental boxes in an effort to overcome the tainting of butter by boxes made of *Pinus radiata* timber. Much spectrographic examination of metals was carried out for industry, and the Coal Survey Laboratory co-operated with the field staffs of the Geological Survey and the Mines Department in a continuation of the physical and chemical survey of the coal resources of the Dominion. Equipment on a pilot-plant scale for the production of penicillin and other antibiotics was designed for installation at the Plant Chemistry Laboratory, and an experimental tray dryer was also designed and installed. A complete survey of all certified plant therapeutic compounds on the market was also undertaken.

The Dominion Physical Laboratory has assisted many New Zealand manufacturing firms with tests

on materials and equipment, the design and supply of special measuring apparatus, replacement parts for machinery and small precision tools, and about half the time of the Laboratory has been spent on similar work for Government Departments. Major investigations during the year included vacuum-pressure impregnation of timber with synthetic resins, the moulding of plywood, the thermal efficiency of open-hearth fires and the design and construction of micro-wave meteorological radar. In addition to its butter-fat investigations, the Fats Research Laboratory has used a molecular still of novel design for the preparation of fish liver-oil concentrates. In addition to vitamin analyses, the Plant Chemistry Laboratory has conducted a successful trial of new hormone weed-killers. Work under the Plant Research Bureau included an extensive breeding programme for garden peas and field peas, as well as for barley and other field crops. A vegetable research section was established, and the Botany Division made further surveys of vegetation and extended its collections of agar seaweed and of carrageen (Irish moss). The Grasslands Division carried out further work on pedigree strains of pasture species, blind-seed disease of rye-grass and soil conservation, while in addition to therapeutic testing the Plant Diseases Division studied tree-tomato mosaic, lettuce mosaic, halo-blight of beans, and soil disinfection. An investigation was also commenced on boron and its relation to the incidence of yellow leaf.

PHOTO-ELASTIC INVESTIGATION OF INTERNAL STRESSES IN SILVER CHLORIDE CAUSED BY PLASTIC DEFORMATION

By J. F. NYE
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INTERNAL stresses in cold-worked metals cannot be investigated fully by means of X-ray diffraction because in most cases the stresses vary considerably in distances comparable with the cross-section of the X-ray beam. For this reason, X-ray methods can indicate only the presence and magnitude of internal stresses, but not their distribution in space. A more powerful and direct method of approach is provided by the photo-elastic effect in transparent crystals. Cubic crystals are particularly suitable, since they are optically isotropic when unstressed; the magnitude and orientation of their birefringence, and its distribution over the crystals, thus give a direct picture of the distribution of internal stress. There is no reason at present for supposing that the plastic deformation of transparent crystals differs fundamentally from that of other crystalline substances, and one may reasonably expect that results derived from experiments on such materials will also be applicable to metals.

Since December 1946 a series of observations has been made on polycrystalline silver chloride, a material that is transparent, cubic in structure, and also very ductile. Rolled sheets, of thicknesses from 0·3 to 1 mm., supplied by the Harshaw Chemical Company of Cleveland, Ohio, showed patches of birefringence when placed between crossed nicols. These patches disappeared when strips cut from the sheets were recrystallized by heating for two hours at 400° C. and cooled slowly. (The melting point of silver chloride is 455° C.). Subsequent plastic deformation of such flat strips gave patterns of birefringence of which an example is shown in Fig. 1. This photograph was taken in white light between the crossed nicols of a polarizing microscope after unloading the strip; the polarization directions of the nicols are horizontal and vertical. Light areas indicate residual stresses. The pattern is not coloured because, with sheets of this thickness, the path differences due to the stress birefringence are smaller than the wave-length of light. The average width of the grains is large compared with the thickness of the sheet. Most of the grains are crossed by one, or sometimes two, sets of light and dark bands, similar to those observed in transparent single crystals by Brewster[1], by Reusch[2], and by Obreimow and Schubnikoff[3]. They appear to be the result of deformation by glide or by kinking[4]. Other interesting points are visible: for example, plastic distortion in grain *A* has evidently contributed to the stress pattern seen in the neighbouring grain *B*. When an external stress is applied to the strip the grains lighten and the progress of further plastic deformation can be watched. (I gave a demonstration of these phenomena at a conversazione held by the Royal Society on May 29, 1947.) A small portion of another strip is illustrated in Fig. 2, also photographed between crossed nicols; several intersecting sets of bands are shown. In Fig. 3 a grain boundary *XX* separates two grains, each of which is crossed by a particularly sharp set of birefringent bands, produced in this case by bending. The polarization directions of the nicols are again horizontal and vertical. If the nicols are turned through 45° the light stripes become dark and the contrast of the pattern is much reduced. Such observations combined with the use of a compensator make it possible to calculate the distribution of stress within the bands.

Fig. 1. × 13

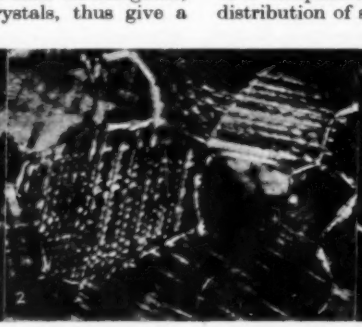

Fig. 2. × 25.

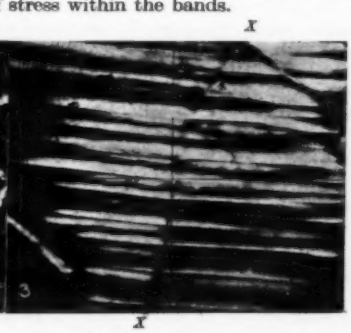

Fig. 3. × 41

Bands of a very similar nature have been reported in diamond by Raman and Rendall[5], and investigated in detail by Ramachandran[6]. These authors attribute the bands to the stresses set up in alternate layers of diamond having two different lattice spacings. It would be interesting to know whether they are not really the consequence of plastic deformation.

Examination of a plastically deformed strip of silver chloride that was annealed in stages shows that heating near the melting point causes a gradual reduction of the intensity of the picture, but leaves the pattern unaltered. We may conclude that, during annealing, there occur no large-scale migrations of dislocations, but only localized processes of atomic rearrangement.

Although they are optically isotropic when unstressed, cubic crystals under stress behave differently from glass and the usual plastics used in photo-elastic tests. The crystal classes T_d, O, O_h require not two but three constants to describe their photo-elastic behaviour, and, as has recently been pointed out[7,8], the T and T_h classes (also in the cubic system) require four. This fact makes the full interpretation of the stress birefringence pattern dependent upon a knowledge not only of certain combinations of these constants, but also of the crystallographic orientation of the grains concerned. It also leads to a striking phenomenon observed in the elastic stress range: when a bending moment is applied to an annealed strip, viewed either between crossed nicols or in a circular polariscope, the grain boundaries are seen to flash out brightly. The effect is completely reversible; if the load is removed the light regions return to their original dark state. The explanation seems to be that, when the bending moment is applied, the light passing through a grain traverses a layer of tension on one side of the strip and a layer of compression on the other side. The birefringence of the two layers cancels out, and the total path-difference between the two oppositely polarized rays will be zero. However, grains with different crystallographic orientations will have different stress-optical constants; consequently, whenever a grain boundary is not perpendicular to the sheet, rays crossing the boundary will pass through different grains on the tensile and compressive sides, and the total path difference will not vanish. In contrast to the grains themselves, therefore, the grain boundaries will be lightened. A more exact mathematical treatment of the effect is possible and its results are supported by other observations, but the above argument contains the essence of the explanation. Such bending moments cause the lightening seen at some of the grain boundaries in Fig. 1.

A fuller account of these and other photo-elastic experiments on plastically deformed materials, carried out with the financial support of the British Iron and Steel Research Association, will be published elsewhere. I am greatly indebted to Dr. E. Orowan for suggesting the possibility of using transparent, polycrystalline materials in the way described and for discussion of the results.

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SCIENTIFIC RESEARCH AND INDUSTRY

SIR EDWARD APPLETON'S address to the Scottish Council (Development and Industry) at Glasgow on February 13 on "Science and the Progress of Industry" will increase the impatience with which the scientific and industrial world awaits the resumption of publication of the annual reports of the Department of Scientific and Industrial Research. Indeed, it could well be held that here again, as in the recent speech at Letchworth of the Lord President of the Council (see *Nature*, February 7, p. 214), by using a speech to a sectional or limited audience, which even in normal times could only be imperfectly reported in the Press, as the occasion for important announcements of policy or disclosure of developments, the Government is showing lack of courtesy to the scientific man and to the industrialist. Such statements should be put on permanent record in a proper fashion. Whatever may be the rights and wrongs of any policy—for example, the present dispute between the Government and the medical profession—it is to be hoped that the Government will learn that it is wiser to court than to flout the expert and professional experience upon the co-operation of which the smooth running of so many Departments of State depends. As Burke once remarked in another connexion, magnanimity in politics is not seldom the truest wisdom, and little minds go ill with a great State department or with a great Empire.

After a tribute to the work of Scottish men of science in the past, Sir Edward suggested that for an overall picture of the pattern of the scientific effort in Great Britain, it is useful to think of its three great sections—research in universities and technical colleges, Government research and research in industry itself—as being situated at the three corners of a triangle and thus linked directly together. He believes that the first task is to foster fundamental research in universities and technical colleges, where the really revolutionary industrial advances usually have their origin. Such fundamental research knows no national frontiers, but Sir Edward paid here a further tribute to the Scottish contribution, before referring more specifically to the essential contribution of the geologist to those problems of making the best use of familiar materials and of developing in the national interest materials so far regarded as economically useless. The Scottish Branch of the Geological Survey was always ready to help, but the problems of application involved belong to other branches of science. If the inquiries now being carried out by the Scottish Council revealed gaps in the facilities available for research, the Department of Scientific and Industrial Research would always be ready to consult with the Council as to how they could best be filled.

Before dealing with the work of the Department itself, Sir Edward indicated a few of the special grants made to workers in the Scottish universities: for example, to Prof. P. I. Dee in Glasgow and Prof. N. Feather in Edinburgh for work on nuclear physics, to Dr. C. Horrex at St. Andrews for work on the relative speeds of the decomposition of certain organic compounds, to Prof. G. D. Preston at Dundee for work on the development and use of the electron microscope, and to Prof. R. N. Arnold at Edinburgh for work on the cutting of metals at high speeds.

Emphasizing then the national character of the thirteen research stations of the Department, Sir Edward admitted that while, for example, the work which is being done in developing the science of building is equally applicable north and south of the Tweed, in considering the application of such science to particular problems, there may be considerable difference between the problems of the south of England and those of Scotland. For this reason, it has been decided to establish at East Kilbride branches of the Road Research Laboratory, the Building Research Station and the Fuel Research Station.

Sir Edward said that in co-operation with the County Surveyor of Lanarkshire and the Ministry of Transport, full-scale experimental surfacings are already under observation in that county. Two of these are duplicates of experiments on the Colnbrook Bypass near London, one being concerned with long-life asphalt and the other with tar and bitumen carpets. The object of both these experiments is to ascertain how far conclusions, valid in the south of England, are also valid in Scotland, where the weather tends to be wetter and cooler. Another experiment in Lanarkshire is concerned with the use of wetting agents to improve the adhesion of bituminous binders to a local stone. The County Surveyor of Ayrshire is co-operating in experiments in the use of quarry waste in bituminous surfaces; the County Surveyor of Wigtownshire in the use of local sands, and the County Surveyor of Dumfriesshire in experiments on the use of chemicals for removing ice from roads.

Again, the Building Research Station has carried out work in conjunction with the Scottish Department of Agriculture on building materials composed of peat and cement, and investigations have been made into the suitability of clays from north-east Scotland for brick manufacture. There is already close association between the Fuel Research Station and the manufacturers and others interested in fuel problems in Scotland; but co-operation will be further strengthened by the establishment at East Kilbride of a sub-station of the Fuel Research Organisation. This sub-station will, in the first place, be occupied mainly in testing domestic heating appliances, but it will also serve as a liaison establishment in dealing with other local fuel problems and will ensure full appreciation at Greenwich of Scottish conditions and preferences.

The new laboratory for research into mechanical engineering science of the Department of Scientific and Industrial Research is also to be erected at East Kilbride. Sir Edward said that when, after the War, the Advisory Council for Scientific and Industrial Research came to review the research needs of Great Britain, certain gaps were evident in the facilities for research in this field. The most important of these were in hydraulic machinery, pumps and so forth, in heat transfer problems, in applied thermodynamics, and in kinetics and mechanisms. It will be part of the job of the new establishment to fill in these gaps; but its main task will be basic research in mechanical engineering science, which will have general application in due course throughout the whole of the industry. The work has been divided into groups which are, in fact, the underlying subjects of general application in many branches of mechanical engineering; in addition to those already mentioned, the properties of metals, problems of vibration, of lubrication, of noise, and of the mechanics of the formation and machine-shaping of metals are included.

Speaking of the research associations, Sir Edward made two interesting comments. Thirty-five industries now possess active research associations, some, such as the Iron and Steel, and the Electrical Research Associations with incomes of the order of £250,000 a year, and all with incomes permitting the prosecution of research on a substantial scale, possibly three or four times the pre-war scale. This increase in the scale of working, he suggested, largely disposes of the basis of previous criticism of co-operative research. Secondly, he referred to the use by certain associations, such as the Cotton, the Refractories and the Iron and Steel Research Associations, of the technique of what was called during the War 'operational research'. In industry this means obtaining a quantitative estimate of the dependence of the efficiency of industrial operations on various factors, and studies already made in some branches of industry have indicated immediate steps which could be taken to increase output by as much as twenty per cent. Statistical studies of a different kind made by the Boot and Shoe Research Association have shown that it is possible to increase the chance of being able to fit any customer and to reduce materially the number of sizes to be manufactured and stocked.

Of research by individual firms, Sir Edward remarked that the ultimate decision on how far new ideas springing from science are to be applied in industry rests with industry itself, and the manner of that application is a problem to be determined by the management. Nor is any generalization possible as to the necessity for, or type of, research department in an individual firm: there are industries which can safely rely on research carried out for them in outside organisations, provided they have the technical staff capable of interpreting the results of the work and applying and developing it to meet their particular requirements. No firm can afford to neglect such development, and Sir Edward insisted that Britain can only remain a great industrial nation if the industrial scene is kept under view and opportunities watched for applying science. This is work that the Scottish Council is well equipped to do for Scotland, and the office which the Department of Scientific and Industrial Research has established in Edinburgh is intended to assist the Council in such work. A main task of this new office is to assist the utilization of existing knowledge by putting the man with the problem into direct touch with the man who can solve it.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, March 8

INSTITUTE OF PETROLEUM, NORTHERN BRANCH (at the Engineers' Club, Albert Square, Manchester), at 6 p.m.—Mr. E. Thornton: "The Fighting of Oil Fires".

ROYAL INSTITUTE OF CHEMISTRY, LONDON AND SOUTH-EASTERN COUNTIES SECTION (at Woolwich Polytechnic, Woolwich, London, S.E.18), at 6.45 p.m.—Dr. H. Baines: "Colour Photography".

TEXTILE INSTITUTE (at 16 St. Mary's Parsonage, Manchester), at 7 p.m.—Dr. B. P. Ridge: "Some Aspects of Synthetic Fibres".

INSTITUTION OF THE RUBBER INDUSTRY, MIDLAND SECTION (at Burton-on-Trent), at 7.15 p.m.—Mr. L. E. Puddefoot: "Rubber Adhesives".

Tuesday, March 9

UNIVERSITY COLLEGE, LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. H. E. M. Barlow: "Applications of Micro Waves".*

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5 p.m.—Prof. W. E. Le Gros Clark, F.R.S.: "Recent Discoveries of Fossil Hominoids in Africa".

ZOOLOGICAL SOCIETY OF LONDON (at the Zoological Gardens, Regent's Park, London, N.W.8), at 5 p.m.—Scientific Papers.

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Sir John E. Lennard-Jones, F.R.S.: "Modern Theories of Chemical Valency". (Further Lectures on March 16 and 23.)

INSTITUTE OF PHYSICS, ELECTRONICS GROUP (at 47 Belgrave Square, London, S.W.1), at 5.30 p.m.—Dr. H. A. Jahn: "Comparison of Atomic and Nuclear Energy Levels".

INSTITUTION OF CHEMICAL ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. W. H. Wheeler and Mr. J. E. C. Topps: "Rocket Propulsion, a Restricted Survey".

INSTITUTION OF CIVIL ENGINEERS (at Great George Street, London, S.W.1), at 5.30 p.m.—Prof. C. A. Hart and Mr. B. F. J. Bradbeer: "Air Survey and the Road Engineer".

ILLUMINATING ENGINEERING SOCIETY (at the Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 6 p.m.—Mr. H. G. Jenkins and Mr. J. N. Bowtell: "High Voltage Fluorescent Tubes".

MANCHESTER GEOGRAPHICAL SOCIETY (at the Geographical Hall, St. Mary's Parsonage, Manchester), at 6.30 p.m.—Mr. John Coatman: "On Musa Ka Musalla".

Wednesday, March 10

INSTITUTE OF PETROLEUM (at Manson House, 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. H. S. Gibson: "The Production of Oil from the Fields of South-West Iran".

BRITISH INSTITUTION OF RADIO ENGINEERS, NORTH-EASTERN SECTION (at Neville Hall, Westgate Road, Newcastle-upon-Tyne), at 6 p.m.—Mr. I. A. Harris: "The Calculation of Electrode Temperatures in the Radio Valve".

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGICAL PANEL OF THE FOOD GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.15 p.m.—Annual General Meeting; at 6.30 p.m.—Papers on "The Microbiological Control of Therapeutic Products".

INSTITUTION OF THE RUBBER INDUSTRY, SOUTHERN SECTION (at the Polygon Hotel, Southampton), at 7.15 p.m.—Mr. A. E. Moulton: "Rubber in Railway Operation".

INSTITUTE OF WELDING, NORTH LONDON BRANCH (at the Technical College, Acton, London, W.3)—Mr. E. Ryalls: "The Bronze Welding of Cast Iron".

Thursday, March 11

EAST MALLING RESEARCH STATION (at Bradbourne, East Malling Research Station, East Malling, Kent), at 4 p.m.—Capt. R. Wellington: "Fruit Research—some Thoughts Past and Future".*

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. D. W. E. Axford and Prof. R. G. W. Norrish, F.R.S.: "Oxidation of Gaseous Formaldehyde"; Sir Alfred Egerton, F.R.S., and Mr. J. Powling: "The Limits of Flame Propagation at Atmospheric Pressure", Parts 1–2.

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—"Survey of the Outer Hebrides". (Dr. James W. Campbell: "Birdlife"; Miss M. S. Campbell: "Plant Collecting".)

PHYSICAL SOCIETY, ACOUSTICS GROUP (joint meeting with the BRITISH SOUND RECORDING ASSOCIATION, at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 5.45 p.m.—Discussion on "Loudspeakers, with Particular Reference to High-Fidelity Monitoring Reproducers" (to be opened by Dr. D. E. L. Shorter).

ANGLO-AUSTRIAN SOCIETY (at the British Council, 6 Hanover Street, London, W.1), at 6.30 p.m.—Prof. J. R. Marrack: "The World Food Situation".*

CHEMICAL SOCIETY (in the Chemistry Department, The University, Manchester), at 6.30 p.m.—Prof. H. L. Riley: "Amorphous Carbon".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (joint meeting with the NOTTINGHAM SECTION OF THE S.C.I., at the Welbeck Hotel, Nottingham), at 7.15 p.m.—Mr. W. Cunliffe: "Physical Chemistry of Food with particular reference to Bakery Products".

CHEMICAL SOCIETY, SOCIETY OF CHEMICAL INDUSTRY, and ROYAL INSTITUTE OF CHEMISTRY, EDINBURGH and EAST OF SCOTLAND SECTIONS (at the North British Station Hotel, Edinburgh), at 7.30 p.m.—Dr. E. S. Paice: "Practical Aspects of Wetting and Detergency".

PHARMACEUTICAL SOCIETY (at 17 Bloomsbury Square, London, W.C.1), at 7.30 p.m.—Sir Weldon Dalrymple-Champneys, Bart.: "The Work of the Medical Staff of the Ministry of Health".

PHARMACEUTICAL SOCIETY, MANCHESTER, SALFORD AND DISTRICT BRANCH (in the Council Chamber, Houldsworth Hall, Manchester), at 7.45 p.m.—Papers on "The New British Pharmacopœia".

BRITISH INSTITUTION OF RADIO ENGINEERS, NORTH-WESTERN SECTION (in the Reynolds Hall, College of Technology, Sackville Street, Manchester).—Mr. M. P. Johnson: "Some Aspects of Moderate Precision Temperature Control in Communication Engineering".

Friday, March 12

BIOCHEMICAL SOCIETY (in the Department of Biochemistry, University College, Gower Street, London, W.C.1), at 2 p.m.—Annual General Meeting; Scientific Papers.

OIL AND COLOUR CHEMISTS' ASSOCIATION, MANCHESTER SECTION (at the Engineers' Club, Albert Square, Manchester), at 2 p.m.—Mr. H. V. Clay and Mr. V. Watson: "Physico-chemical Studies of Lead Chromes".

PHYSICAL SOCIETY (in the Physics Department, Imperial College of Science, Imperial Institute Road, London, S.W.7), at 5 p.m.—Scientific Papers.

INSTITUTE OF NAVIGATION (at the Royal United Services Institution, Whitehall, London, S.W.1), at 5.30 p.m.—Mr. P. F. Everitt: "Air Sextants"

BRITISH ASSOCIATION OF CHEMISTS, BIRMINGHAM SECTION (at the University, Edmund Street, Birmingham), at 6.30 p.m.—Prof. W. Wardlaw: "Valency".

INSTITUTE OF PHYSICS, MANCHESTER AND DISTRICT BRANCH (in the New Physics Theatre, The University, Manchester), at 7 p.m.—Prof. P. A. Sheppard: "The Physics of Meteorology".

SHEFFIELD METALLURGICAL ASSOCIATION, METHODS OF ANALYSIS GROUP (at 198 West Street, Sheffield), at 7 p.m.—Mr. H. Gross: "Absorptiometric Determination of Manganese".

CHEMICAL SOCIETY (in the Chemistry Lecture Theatre, The University, Glasgow), at 7.15 p.m.—Prof. E. L. Hirst, F.R.S.: "Some Problems in the Chemistry of Starch and Glycogen".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. T. E. Allibone: "Lightning and Spark Phenomena".

Saturday, March 13

NUTRITION SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 10 a.m.—Conference on "Results of Recent Investigations into Nutritional Status in Great Britain".

BRITISH PSYCHOLOGICAL SOCIETY (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 2.30 p.m.—Mr. J. C. Raven: "The Comparative Assessment of Intellectual Ability".

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Dr. M. Fortes: "The Cocoa-Farmers of the Gold Coast".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT CHEMIST IN THE INDIA STORE DEPARTMENT—The Director-General, India Store Department, Blackpool, quoting S.4527/48 (March 8).

AREA SUPERVISORS OR ASSISTANT AREA SUPERVISORS, and a LABORATORY STEWARD, in the West Midland Province—The Provincial Supervisor, National Milk Testing Service, Ministry of Agriculture and Fisheries, Bank House, Newport, Shropshire (March 12).

LECTURER IN AGRICULTURE AND FARM BOOKKEEPING, and a LECTURER IN AGRICULTURE, FARM IMPLEMENTS, BUILDING CONSTRUCTION, etc., at the Cheshire School of Agriculture, Reaseheath—The Director of Education, County Education Offices, City Road, Chester (March 13).

AGRICULTURAL ADVISER for the County of Angus—The Secretary, Edinburgh and East of Scotland College of Agriculture, 13 George Square, Edinburgh 8 (March 15).

ASSISTANT LECTURER IN THEORETICAL PHYSICS—The Registrar, The University, Manchester 13 (April 17).

CHIEF MINING ENGINEER, Salt Range Division, Khewra, West Punjab—The High Commissioner for Pakistan, 16 Fitzhardinge Street, London, W.1 (March 19).

PHYSICAL-CHEMIST to work on chemical reactions in emulsion systems, a PHYSICIST or PHYSICAL-CHEMIST to work on properties of plastic-elastic materials, and a CHEMIST with experience of abstracting, etc.—The Secretary, Research Association of British Rubber Manufacturers, 105 Lansdowne Road, Croydon, Surrey (March 27).

FORECASTERS IN THE METEOROLOGICAL BRANCH, Air Department, New Zealand—The Office of the High Commissioner for New Zealand, 415 Strand, London, W.C.2 (March 31).

ROBERT BLAIR FELLOWSHIPS IN APPLIED SCIENCE AND TECHNOLOGY—The Education Officer (H.1/2), London County Council, County Hall, London, S.E.1 (April 1).

SENIOR PRINCIPAL SCIENTIFIC OFFICER in the Royal Naval Scientific Service—The Secretary, Civil Service Commission, Scientific Branch, 27 Grosvenor Square, London, W.1, quoting No. 2123 (April 7).

ASSISTANT EDITOR—The General Secretary, Chemical Society, Burlington House, Piccadilly, London, W.1 (April 12).

RAMSAY MEMORIAL FELLOWSHIPS FOR CHEMICAL RESEARCH—The Joint Honorary Secretaries, Ramsay Memorial Fellowships Trust, University College, Gower Street, London, W.C.1 (April 17).

HEAD OF THE DEPARTMENT OF SURVEYING AND ENGINEERING—The Principal, College of Estate Management, 11 Great George Street, London, S.W.1 (May 1).

ASSISTANT LECTURER (Grade III) IN THE DEPARTMENT OF BIOCHEMISTRY—The Registrar, The University, Liverpool (May 1).

DENTAL RESEARCH FELLOW—The Dean, Medical School, Guy's Hospital, London, S.E.1 (May 31).

PROFESSOR OF CIVIL ENGINEERING in the University of Queensland, Brisbane—The Agent-General for Queensland, 409 Strand, London, W.C.2, and The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (Brisbane, May 31).

HEAD OF THE NATIONAL COLLEGE FOR HEATING, VENTILATING, REFRIGERATION AND FAN ENGINEERING—The Clerk to the Governors, Borough Polytechnic, Borough Road, London, S.E.1.

LABORATORY TECHNICIANS with experience in cutting and staining sections—The Dean's Office, St. Thomas's Hospital Medical School, London, S.E.1.

RESEARCH ASSISTANTS (with Inter.B.Sc.) for work in Organic Chemistry section, in Leatherhead—The Assistant Secretary, British Coal Utilization Research Association, 13 Grosvenor Gardens, London, S.W.1.

DEMONSTRATOR IN THE DIVISION OF CHEMISTRY—The Bursar, Royal Veterinary College and Hospital, Royal College Street, London, N.W.1.

BIOCHEMIST (male, with B.Sc. chemistry) in charge of routine hospital biochemical laboratory—The Secretary, Ministry of Health Laboratory, Peace Memorial Hospital, Watford.

DEMONSTRATOR IN THE PHYSIOLOGY DEPARTMENT—The Warden and Secretary, Royal Free Hospital School of Medicine, 8 Hunter Street, London, W.C.1.

TECHNICIANS (2, Grade B)—The Medical Director, Coventry Joint Laboratory, Stoney Stanton Road, Coventry.